PRIVATE
DEPOSITORY

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LX. No. 7. APRIL 1900.

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E. B. KNOBEL, Esq., PRESIDENT, in the Chair.

Thomas C. Bush, Somerville, Wells Road, Bath, was balloted for and duly elected a Fellow of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended : —

Louis Napoleon George Filon, M.A., Fellow of and Lecturer on Astronomy at University College, London, Godwin House, St. Augustine's Avenue, South Croydon (proposed by H. F. Newall) ;

Forest Ray Moulton, Ph.D., Instructor in Astronomy at the University of Chicago (proposed by George E. Hale) ;

William Harrison Pearsall, Higher Grade School, Dalton-in-Furness (proposed by H. A. Wassell).

Seventy-eight presents were announced as having been received since the last meeting, including, amongst others :—

Royal Observatory, Cape of Good Hope, Reference Catalogue of Southern Double Stars, and Catalogue of 2789 Zodiacal Stars ; Royal Observatory, Greenwich, Observations, 1897 ; Harvard Observatory Annals, Vols. 32, 33 (Visual Observations of the Moon and Planets, W. H. Pickering ; Miscellaneous researches) ; Lund Observatory, Observations des étoiles de la

zone entre 35° et 40° N.; Paris Observatory, Carte photographique du ciel, Zone 24 (24 Charts), presented by the Observatories; S. de Glasenapp, Mesures micrométriques d'étoiles doubles; H. L. Rice, Theory and Practice of Interpolation; G. V. Schiaparelli, Osservazioni del pianeta Marte, 1888, presented by the authors; Photographischer Mond-Atlas, Heft 7, 8, presented by Prof. Weinek; Photograph of a meteor (lantern slide and enlargement), presented by C. P. Butler; Bronze copy of the Jubilee Medal of the Royal Meteorological Society, presented by the Society.

On Stationary Radiants of Meteors. Reply to the Criticisms of M. Th. Brédikhine. By H. H. Turner, M.A., F.R.S., Savilian Professor.

In *Monthly Notices, R.A.S.*, vol. lix. p. 140 (1899 January), I suggested an explanation of the stationary or long-enduring radiant points which Mr. W. F. Denning has so long and faithfully declared to be the outcome of his observations. In the *Bulletin de l'Acad. Imp. des Sciences de St. Pétersbourg* for January last (T. xii. No. 1), M. Th. Brédikhine has done me the honour to examine my suggestion at some length, though he ultimately dismisses it as leading to a totally different result from that which it endeavours to explain. He declares that I have forgotten to take account of the fact that the Earth's path is curved, and that my explanation would only hold good if the Earth moved in a straight line. I hope, however, to show that the mistake is his own, and that my suggested explanation remains untouched.

My suggestion was briefly this. Suppose we have originally a swarm of meteors crossing the Earth's orbit at a point N_0. The action of the Earth in passing again and again through the swarm will cause some of the meteors to describe new orbits crossing the Earth's orbit at a point N_1 displaced from N_0 in the direction opposite to that of the Earth's motion, but without altering the average *relative* motion of the Earth and meteors. Some of these, again, will be caused to describe new paths crossing the Earth's orbit at N_2, and so on, so that ultimately, instead of the point N_0, we have a long series of points N_0 N_1 N_2.

In the ordinary language of meteoric theory the point N is called the node, and it is a quite familiar idea that the node should be made to regrede in this way by the perturbations of the Earth. I merely avoid using this familiar language because there are two unfamiliar ideas on which I wish to insist which are liable to be overlooked if we think of the motion of the node as it would occur for a planet. These points are:

First, that the crossing-point of the swarm does not move as a whole; for some members of the swarm it remains unaffected, for

others it moves rapidly, and for yet others it moves with intermediate velocities, so that instead of a single crossing-point we ultimately get a series distributed round the orbit. Hence instead of the familiar retrogression of the node we have a *distribution* of the crossing-point along the orbit. I have given the reasons for this view in my paper above quoted, and as M. Brédikhine does not criticise them, I do not reproduce them here.

Secondly (the main point of my paper), the velocity of the meteors at the crossing-point *relative to the Earth* remains unchanged during the displacement or distribution. Now, for this perfectly definite geometrical notion M. Brédikhine has substituted a completely different one, as follows : Suppose we draw from the crossing-point N a line NR to represent the relative velocity of the meteors in magnitude and direction, and a line NA to represent the absolute velocity or velocity in space, and let NE represent the velocity of the Earth. My principle (reasons for which are given in my paper at some length) is that NR remains constant in length and direction. Hence NA, which is obtained by combining NR with NE, varies both in length and direction as N moves round the orbit. There is no difficulty in tracing these changes if this be desired ; but it is clear that the simplest account of what happens is given in terms of NR and not of NA. Nothing could be simpler than that NR remains constant.

M. Brédikhine, however, fixes his attention upon NA, the velocity in space. He assumes that NA remains constant *in length* and in *direction relative to* NE. In fact he assumes that as N rotates round the orbit it carries with it the two lines NE and NA as though they were rigidly attached to the radius SN from the Sun to node. Naturally, therefore, the diagonal NR of the parallelogram formed by NA and NE rotates with them, and is anything but fixed in direction. There is no need to prove this by a page of spherical trigonometry (p. 114 of M. Brédikhine's paper), and it may save others wading through an argument which would have been made easier by a figure if I point at once to the place where M. Brédikhine has made this wholly unwarranted assumption, viz. at the top of p. 115 of his paper, where he writes

$$l' = l - 5^\circ, \quad b' = b.$$

Here l and b are the longitude and latitude of the velocity of the meteors in space when the node is in a position N, and l' b' are the longitude and latitude when N has moved through 5°. This shows that he treats NA as rigidly attached to the radius vector SN (or the direction of the Earth's motion NE, which amounts to the same thing) in *direction* ; that he treats it as constant in magnitude is less obvious, but appears from the derivation of the coordinates (λ' β') for the relative velocity, *i.e.* for the radiant. He even takes the trouble to convert longitude and latitude into R.A. and Decl., as though that might affect matters !

Now, I cannot but think that this complete misconception of my meaning arises from regarding the phenomenon to which I wished to draw attention as a motion of the node, with the associations which this familiar idea calls up. M. Brédikhine has visualised the actual orbit of the meteors as being simply rotated about the Sun ; this is very far indeed from the conception I wish to put before astronomers. It may be that my conception is not deducible from facts, though I feel more and more convinced of its truth myself ; but at any rate, if true, it leads at once to a stationary radiant—there ought not to be the least difficulty in admitting so much. If, on the other hand, M. Brédikhine's conception is deducible from facts, I should be the first to acknowledge that a radiant cannot be stationary, without any calculations at all ; but I cannot see that anything he has said in his paper supports his view in the least degree. His investigation in the earlier part of the paper as to what happens to a meteor after a pair of encounters with the Earth supports, so far as it goes, either my view or his own : he proves that a small motion of the node will result ; but he proves nothing conclusive as to the changes in velocity either real or apparent ; indeed, he never examines the velocity of the meteor at all—he merely *assumes* that the velocity in space remains sensibly parabolic, and this assumption I regard not only as unproved but as quite erroneous.

As the principles I have advocated are thus apparently liable to be misunderstood, I will venture to repeat in somewhat different form my main argument.

If the Earth were at rest, and a meteor passed near it, its path would be deflected. The whole effect of the Earth's action may be summed up by considering the state of affairs when the meteor enters the "sphere of influence" of the Earth and when it leaves it.

(*a*) The magnitude of the velocity at entering and leaving is the same.

(*b*) But the direction is altered, being deflected in a plane through the Earth's centre.

(*c*) The time of passing through the sphere of influence is shortened ; that is, if the time which would be spent within this sphere if the Earth were annihilated be T, then, when the Earth is replaced, the time will be $T-t$; because the velocity of the meteor is always increased by the Earth's attraction and never diminished.

Now, by assuming a *pair of* passages through the sphere of influence symmetrically disposed on opposite sides of the Earth we have

(*a*) The magnitude of the velocity still unchanged.

(*b*) The deflections being equal and opposite in the two cases neutralise each other, and the total deflection is zero. Hence the velocity is now the same on leaving the sphere *in magnitude and direction* as on entering it. [As regards the magnitude,

however, there may be a diminution of the kind suggested at the end of this paper.]

(*c*) The total time spent within the sphere of influence is still further shortened. Hence, let us disregard entirely what happens while the meteor is within the sphere of influence; suppose, for instance, that we entirely lose sight of it, and only know the following facts:—

It enters with a certain velocity.

If there is no Earth inside the sphere it emerges with the same velocity after time T.

If there *is* an Earth inside it emerges still with the same velocity, but after a shorter interval, $T-t$.

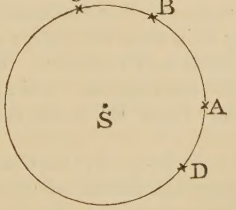
Now, what is true for the actual motion of the meteors when the Earth is at rest is true for the relative motion when the Earth and meteors are both in movement and both acted on by the same forces, as, for instance, the attraction of the Sun. The attraction of the Sun on Earth and meteors while the latter are within the sphere of influence of the Earth is sensibly the same; the difference is the "disturbing force" of the Sun familiar in lunar theory, very small even for the Moon, and very much smaller for meteors passing close to the Earth—in fact, quite negligible.

Hence, the meteors obey the laws above stated for their relative motion, viz.—

They ultimately emerge from the sphere of influence with the same velocity *relative to the Earth* with which they entered it.

This happens whether the Earth is existent within the sphere or is supposed annihilated; the only difference is that in the former case the meteors emerge after a time $T-t$, in the latter after a longer interval T.

Now, remark that these laws hold *independently of the time spent within the sphere of influence.* We cannot extend this time indefinitely, for that would mean that the meteor would describe



a complicated orbit near the Earth; but we can suppose it extended to such a length that the Earth's path is sensibly curved during the period. Let, then, T be a sensible fraction of a year, so that the Earth's path can no longer be taken as straight, but is sensibly curved. [M. Brédikhine has suggested that I have been misled by considering only a small straight portion of the path. I think he is mistaken.]

Let, then, T be such a time that during it the Earth describes an arc AC (much exaggerated in the figure) of its orbit round the Sun S ; and let the meteors enter the sphere of influence at A. If we suppose the mass of the Earth annihilated they will emerge again with the same relative velocity at C. The effect of the Sun's attraction has been to make both Earth and meteors describe the curved path AC during the interval, but has not disturbed their relative motion, which remains unchanged throughout.

We need not suppose the Earth annihilated, but merely that it does not happen to be at A when the meteors come. The sphere of influence can still be described, but it is to be regarded as empty. This may happen many times, and the meteors will continue to enter at A and emerge at C, their orbit forming a sort of long contact with that of the Earth.

But there will come a time (the periods of Earth and meteors being incommensurable) when some meteors arrive at A to find the sphere of influence with an Earth inside it. The effect will be that they will be ejected earlier than before, say at B ; but still with relative velocity unaltered (if we are allowed to combine the effect of a pair of symmetrical encounters into one). Their orbit will at the next return enter the sphere of influence at D and leave it at B, where AD = BC ;* and unless another encounter with the Earth occurs, the orbit will be permanently shifted round through the arc CB, or AD. But the velocity of the meteors *in space* at D is not the same as the *velocity in space* was at A either in magnitude or direction ; nor is it obtainable from the velocity at A by rotation round S as M. Brédikhine suggests : the arc AC is subject to such a simple rotation and becomes the arc DB, but to find the new velocities in space at D and B we must combine with the *unchanged relative* velocity, the changed velocities of the Earth.

The constancy of the relative velocity is in fact maintained quite independently of what happens to both Earth and meteors during the time spent in the sphere of influence so long as both are affected equally. Suppose, for instance, that a giant comet were to rush by during this time and cause a considerable change in the orbits of both Earth and meteors. The relative motion at parting would still be unchanged, which means that these meteors would still come from the same radiant point as before.

May I now consider a weakness in this theory of the distribution of the crossing-point round the Earth's orbit which was pointed out by Professor S. Newcomb, who very kindly discussed it with me at some length during his visit to Oxford last year? I have

* This is easily seen by considering all the motions reversed when the meteors are about to leave the sphere of influence. In the first case, if they are sent back again at C they emerge after time T at A. If sent back again at B, and if now the Earth be absent from the sphere of influence, they will similarly emerge again after the same time T at D, where CA = BD, or CB = AD. The orbit of the Earth is of course here regarded as circular.

thought over his criticism many times since, and I think it may be answered. It may be stated as follows : Admitting for the sake of argument that the perturbing action of the Earth on a meteor swarm is of the kind described in my paper and briefly reproduced above, it is so small at any one encounter that a large number of encounters and a long period of time are necessary for any sensible distribution of the crossing-point. Now, the general perturbations exercised by the other planets on the orbit of the meteor swarm will cause it to slowly change, so that those meteors which passed close to the Earth at one time will gradually pass further and further from it, new ones taking their place. The action required will thus never accumulate to sensible proportions.

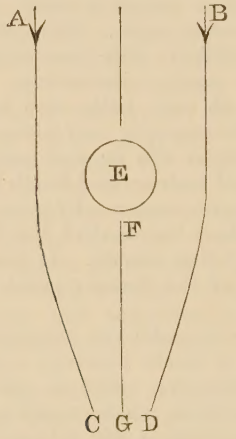
My answer to this very pertinent objection is as follows :—

In the first place, if we assume that the velocities of meteors are parabolic, their velocities relative to the Earth are so large, and they rush through the sphere of influence so quickly, that the effect I have indicated is certainly small. I have shown how small it is in my previous paper. But are we very clear as to the size of these velocities? Our knowledge of meteoric velocities is based on very scanty information. Mr. Denning is of opinion that it is worth very little, and he has a right to an opinion if anyone. Photography may ultimately help us in this respect; but meanwhile it will be well not to be too sure that the relative velocities of meteors and Earth may not be comparatively small. There is no reason why some meteors should not be describing orbits rather like that of the Earth ; indeed, there are many reasons why they should. If the relative velocity is small the distribution of the crossing-point may be effected with much greater rapidity.

Secondly (and here I make the suggestion with some diffidence, but yet I think it worth making), is it not possible that the Earth has an attractive effect on the orbits of meteors passing near it, so that those which would otherwise be carried away by planetary perturbation are retained, and perhaps even those which originally passed wide of the Earth's orbit are drawn towards intersection with it? If this were the case it would explain several things—not only would it complete the above theory of stationary radiants without any difficulty, but it would explain the large number of meteors encountered by the Earth without assuming that all space was full of meteor swarms.

To show how such an action might be possible, take the case with which I originally started, of two meteors, AC, BD, passing on opposite sides of an Earth, E, supposed at rest. Their paths are deflected towards each other equally and in opposite directions ; so that, if everything were exactly symmetrical, the meteors would collide after the encounter. If they were perfectly inelastic they would then proceed together along the central line FG with diminished velocity, viz. the resolved component of the deflected velocities in the direction FG.

Now, to imagine two single meteors meeting in collision in this way is almost ridiculous. But when we consider a whole swarm of meteors originally travelling in parallel lines, then there will be after the passage near the Earth a considerable convergence of the swarm towards the line FG, which will almost certainly result in a number of collisions or entanglements, the general effect of which would be (except in the improbable case of the meteors behaving like perfectly elastic particles), that some of the velocities perpendicular to FG, the general direction of motion, would be destroyed. The convergence is symmetrical with respect to the line FG (other things being equal), and for inelastic particles we can imagine a complete destruction of velocity perpendicular to FG, so that all the paths then coincided with FG. At the next return the meteors so affected would then all pass through the position occupied by



the Earth's centre. If the Earth were still there, they would of course fall on the Earth and be seen as meteors ; if not they would pass through this point on the Earth's orbit instead of all passing wide of it as before ; and this is exactly the sort of action above suggested—a tendency to draw the points in which the meteor orbits cut the ecliptic nearer to the actual path of the Earth. To suppose the whole swarm symmetrically distributed round the Earth, and the subsequent collisions to resemble those of inelastic particles, is of course an extreme supposition ; but it is one towards which the actualities must approximate in some degree, and hence cause is shown for a tendency in the direction indicated.

We may regard the matter from another and more familiar standpoint. When we see in the sky a nebula with a nucleus we do not find any difficulty in imagining that the nebu-

lous matter is condensing towards the nucleus; indeed, it is the natural supposition. It would be still perfectly natural if the nucleus, instead of being permanently in place, were to appear there only at comparatively rare intervals, being annihilated in the meantime. The condensation would proceed more slowly, but would proceed nevertheless. If, again, the nucleus made these visits by actually passing through the nebulous mass periodically along a certain line, then the condensation would be towards this line generally, and not towards any particular point of it. If, further, the path of the visiting body were not a fixed line, but any one of a series of lines forming a surface, the condensation would be towards this surface.

Now, this is surely just what is happening with a meteor swarm. To a spectator carried with the swarm, and unconscious of its motions in space, the Earth appears as a periodical visitor passing through the swarm. Its path always lies on a certain surface, viz. the surface described in the swarm by the Earth's orbit whenever the swarm crosses this orbit. Hence the swarm will gradually condense towards this surface, and so *tend* to become a sheet which passes through the Earth's orbit, or rather through which the Earth's orbit sweeps at successive returns. This tendency may not be very strong, owing to the rarity of the Earth's visits, but I do not see why it should not be stronger than the perturbing influence of the other planets, considering their remoteness compared with the proximity of the Earth. Such considerations would only apply to swarms which originally passed near the Earth. Those in the neighbourhood of other planets would be similarly collected by them into sheets passing through *their* orbits; and in the case of the giant planets, like *Jupiter*, the condensation would be much greater. Could these condensations of meteor swarms ultimately form comets? Have we here a clue to the established connection of comets and meteors, and to the association of periodical comets with the major planets?

That such general speculations are hazardous I am only too well aware. I put them forward with due apologies. My main point is this. We have the statement of a thoroughly experienced observer that certain meteor radiants are stationary or persistent. That this observer knows what he is saying is evident from the fact that he distinguishes other radiants which are *not* stationary; and, further, there are tests which may be applied to his observations generally which have not yet shown them to be otherwise than excellent. Starting, then, from this observed fact, can we suggest an explanation of it? M. Brédikhine's "explanation," of course, does not count, as it is a simple denial of the main fact. Mr. Denning claims the physical connection of certain radiants appearing in the same part of the sky in different months; M. Brédikhine denies the physical connection, and attributes the connection to chance, and in this he has a large following. Is there any good reason for this scep-

ticism or positive disbelief until possible causes for the fact have been examined? I have endeavoured to indicate a possible cause in the simple attraction of the Earth. The considerations I have adduced are not very thoroughly established, but they point in the right direction, and do not demand any new supposition. Further, they are not at variance with known results of more elaborate mathematical investigations; and that they are not capable of being fully confirmed by, or compared with, such results at once is due to the fact that mathematical investigations have not yet been carried far enough. The perturbations of a planet on a swarm of meteors considered as a whole have been examined, but not the selective action on different parts of the swarm, and certainly not the interaction of differently affected parts. Until this has been done, why should we deny the possibility of the facts which Mr. Denning claims as observed facts?

Observations of the Leonids made at the Cambridge Observatory on 1899 *November* 13, 14, 15. By Arthur R. Hinks, M.A.

1. The observations to be discussed were made by a number of members of the University who had volunteered to assist in securing as complete a record as possible of the expected Leonid shower. My acknowledgments are due, first, to Mr. John C. W. Herschel, B.A., Research Student in Astronomy, St. John's College, who has taken a large part in the preparations, observations, and discussion of the results; and, secondly, to the following gentlemen: Messrs. J. F. Cameron, B.A., Fellow of Caius College; L. E. H. R. Barker, B.A., A. L. Hall, B.A., and H. E. Wimperis, Caius College; R. W. H. T. Hudson, B.A., A. B. Field, and M. Walker, St. John's College; W. E. Hartley, B.A., and G. W. Walker, B.A., Trinity College; F. M. Oldham, B.A., Trinity Hall.

We attempted three things:—

I. A continuous count of all meteors seen (five observers).
II. Records of trails from visual observations (two observers and a timekeeper).
III. Records of trails photographically (three observers).

The weather was on the whole not unfavourable, though we suffered from a thick haze late on the night of the 14th, when the shower was least feeble.

I. Horary numbers of observed Leonids.

2. Four observers watched continuously on the nights of the 14th and 15th, dividing the sky among them; and a fifth recorded every five minutes the counts of the four. The numbers

of meteors recorded as Leonids are given below. It is probable that meteors from neighbouring radiants have not been entirely eliminated from the count :

1899 Nov. 13.		Nov. 14.		Nov. 15.	
		h m h m		h m h m	
Clouds with occasional breaks until 17^h, then clear.		12 5 to 13	4	12 25 to 13	2
		13 „ 14	13	13 „ 14	9
h h m		14 „ 15	17	14 „ 15	11
17 to 18	20	15 „ 16	8	15 „ 16	5
18 „ 18 25	3	16 „ 16 35	3	16 „ 17	19
		From $14\frac{1}{2}^h$ fog gradually rose, and after $15\frac{1}{2}^h$, only brighter stars visible. Clouded over at $16\frac{1}{2}^h$.		17 „ 18	21
				18 „ 18 30	5
				From $15\frac{1}{2}^h$, light clouds at times	
Totals	23		45		72

In his spare time the recorder attempted an estimate of the magnitudes of any meteors he saw :

	Nov. 13.	Nov. 14.	Nov. 15.
a. Brighter than Jupiter	0	3	3
b. Between Jupiter and α Leonis	3	9	14
c. Between α and η Leonis	6	15	16
d. Fainter than η Leonis	6	11	18

II. Radiant points deduced from the visual observations.

3. Charts for recording the trails were prepared as follows :— The coordinates of all stars down to the fourth magnitude in a field having a radius of about 65° around the radiant were calculated for a gnomonic projection on the plane tangent to the sphere at the radiant. From these a map was plotted on millimetre paper to the scale tan 45°=1=100 mm. A set of needles of graduated diameters, broken across, and with the ends ground flat, were mounted in wooden handles. Sheets of paper, dark-blue one side and white the other, were laid, half-a-dozen at a time, blue side downwards, between the map and a sheet of lead, and the stars were punched through with needles of sizes appropriate to the magnitudes. The charts were laid on a tall desk of which the top was ground glass, and were illuminated from below by electric light. The stars stood out bright on a dark-blue ground, which did not dazzle the eye ; and the trails were drawn in pencil on the white side, which was uppermost, by means of transparent celluloid rulers, of which not much more than the edge was visible on the charts. This plan was suggested to me by Mr. Herschel. It is entirely satisfactory ; and the

only modification we shall make on a future occasion will be the substitution of night-lights for electric lamps. The heat from the latter was not sufficient to keep the charts from being covered first with dew and then with ice.

A copy of the chart, with a catalogue of the positions of the stars on the gnomonic projection, is placed in the Library.

4. The number of trails plotted was :

November	13	15.
„	14	11.
„	15	33.

Of these there were many that came from the general direction of *Leo*, but were clearly not true Leonids, and it was necessary to decide which should be included in the determination of the radiant point. Denning has given in the *Observatory* (1897, xx. 306), and in his General Catalogue (*Memoirs R.A.S.* vol. liii.) the positions of a number of radiants near *Leo*, all of which furnish in November swift streak-leaving meteors indistinguishable in appearance from Leonids. These were afterwards plotted on the map. They are clustered so thickly round *Leo* that it is somewhat difficult to pick out a trail which cannot be assigned with some probability to one or more of them. Even the small number of observations which we obtained gave, however, some evidence confirming the existence of definite radiation from two of these points ; and this will be considered later.

We eventually decided to reckon as true Leonids seven trails on the 13th, eight on the 14th, and eleven on the 15th.

In two or three cases the same meteor was plotted on two maps. These have been reduced as if they were observations of separate meteors, which is a convenient method of weighting the doubly observed meteor if the radiant is assumed to be strictly a point, but is perhaps not quite justifiable if it is an area of which we wish to determine the mean centre.

5. The displacement of the position of the apparent radiant point due to the attraction of the Earth on the meteors was calculated according to the theory of Schiaparelli. Tables for facilitating the computation are given in his treatise, "Entwurf einer astronomischen Theorie der Sternschnuppen," pages 65 and 109 ; and are reprinted in Valentiner's "Handwörterbuch der Astronomie," vol. ii. pp. 167, 168.

I assumed that the apparent radiant on November 14, 15^h was in R.A. 149° Decl. +23° (Clark, *Monthly Notices*, 1899 December, vol. lx. p. 169). The elongation ψ of the apparent radiant from the apex of the Earth's way was then 9°·8.

Assuming for the major axis of the meteor orbit 10·34 we have for the velocity of the meteors at their node on the Earth's orbit $v = \sqrt{1{\cdot}90}$, the velocity of the Earth being taken as unity.

The undisturbed velocity of the meteors relative to the

Earth comes out $v_0 = 2{\cdot}353$; the velocity is increased by the Earth's attraction to $v = 2{\cdot}383$; and the apparent radiant when on the horizon is displaced towards the zenith by an amount $\Phi = 0^\circ\ 43'{\cdot}8$.

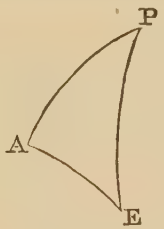
The displacement η for a given zenith distance ζ is then

$$\tan \tfrac{1}{2}\eta = \tan \tfrac{1}{2}\Phi \,.\, \tan \tfrac{1}{2}\zeta.$$

If q is the parallactic angle the displacements in R.A. and Decl. are $\eta \sin q$, $\eta \cos q$ respectively. Their values are given in the table :

Hour-angle.	18^h.	19^h.	20^h.	21^h.	22^h.	23^h.	24^h.
$\eta \sin q$	$-20'{\cdot}6$	$-17'{\cdot}9$	$-14'{\cdot}6$	$-11'{\cdot}2$	$-7'{\cdot}5$	$-3'{\cdot}4$	$0'{\cdot}0$
$\eta \cos q$	$+24{\cdot}4$	$+20{\cdot}1$	$+16{\cdot}8$	$+14{\cdot}4$	$+12{\cdot}7$	$+11{\cdot}8$	$+11{\cdot}4$

6. The displacement of the position of the apparent radiant due to the rotation of the Earth was calculated as follows :— Let P be the pole ; A the apparent radiant ; E the apex of the



diurnal motion of the observer ; that is, the eastern point of the celestial horizon.

The velocity of an observer in the latitude of Cambridge is $0{\cdot}285$ km. per second ; and the velocity of the meteors, corresponding to $v = 2{\cdot}38$ is $70{\cdot}4$ km. per second. If then $k = \frac{0{\cdot}285}{70{\cdot}4}$ ($\log k = \bar{3}{\cdot}6072$) the displacement of A towards E is very nearly $k \sin \mathrm{AE}$. And if h is the hour angle west of A

$$\text{displacement in R.A.} = k \sin \mathrm{AE} \sin \mathrm{PAE}$$
$$= k \cos h.$$
$$\text{displacement in decl.} = k \sin \mathrm{AE} \cos \mathrm{PAE}$$
$$= k \cos \mathrm{AP} \sin h.$$

The values of these displacements for the Leonid radiant are given in the table :

Hour-angle.	18^h.	19^h.	20^h.	21^h.	22^h.	23^h.	24^h.
$\Delta\alpha$	$0'{\cdot}0$	$+3'{\cdot}6$	$+7'{\cdot}0$	$+9'{\cdot}8$	$+12'{\cdot}0$	$+13'{\cdot}5$	$+13'{\cdot}9$
$\Delta\delta$	$-5{\cdot}4$	$-5{\cdot}3$	$-4{\cdot}7$	$-3{\cdot}8$	$-2{\cdot}7$	$-1{\cdot}4$	$0{\cdot}0$

7. The Leonid shower extends over so few days that it does not seem possible at present to decide whether (1) the *true* radiant is stationary, and consequently the motion of the *apparent* radiant in latitude and longitude variable; or (2), as in the case of the Perseids, the motion of the *apparent* radiant is uniform in longitude and zero in latitude, in which case the *true* radiant is not stationary.

I have therefore not attempted to include in the reduction the effect of the orbital motion of the Earth, but have reduced each day's results separately.

8. The diagram exhibits the motions of the apparent radiant due to the separate effects of the attraction of the Earth and its rotation, and also the resulting motion due to the combination of the two.

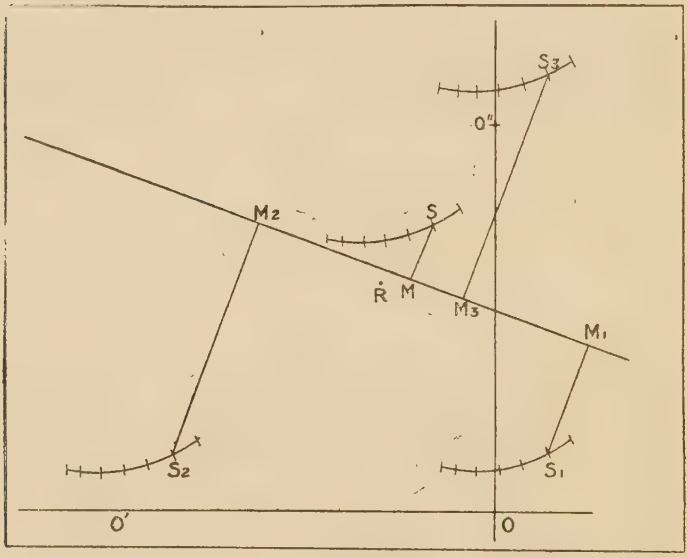


FIG. 1.

9. The radiant points were derived by an elegant graphical process given by Schiaparelli on p. 254 of his treatise (German edition).

The prolongation of the trails near the radiant point were transferred to millimetre paper on a scale ten times the original maps.

Let O be the origin of coordinates; R the position of the undisturbed apparent radiant to be derived from our observations; S the point on the curve of position of the displaced radiant corresponding to the time of appearance of a meteor; SM the perpendicular upon the observed trail. Schiaparelli

shows that if R is the most probable radiant given by the observations the sums of the projections upon the coordinate axes of all the perpendiculars such as SM are each zero.

We can therefore determine R as follows :—Take two points O′ O″ on the axes. Draw about O, O′, O″ as origins the curves of displacement of the apparent radiant. From the points on these corresponding to the time of appearance of meteor draw the perpendiculars on its trail. (In practice find by a square the feet of the perpendiculars, and read off their coordinates directly.)

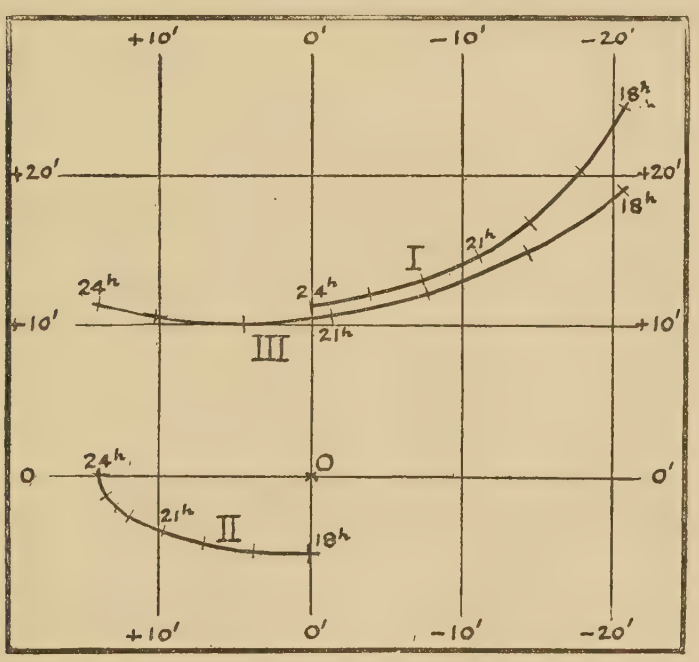


Fig. 2. O is the undisturbed radiant.
I „ Zenith Attraction curve.
II „ Diurnal Aberration curve.
III „ combination of I and II.

If now the sums of the projections on the axes of all the perpendiculars of the three sets O, O′, O″ be S, T ; S+ΔS, T+ΔT ; S+Δ′S, T+Δ′T ; the coordinates x, y of R are given by

$$o = S + \frac{x}{OO'} \cdot \Delta S + \frac{y}{OO''} \cdot \Delta' S.$$

$$o = T + \frac{x}{OO'} \cdot \Delta T + \frac{y}{OO''} \cdot \Delta' T.$$

The observations for the three nights were treated in this manner, and the rectangular coordinates of the apparent radiants referred to an origin in R.A. 150° ; Decl. +22° (the centre of our projection) were

Date.	x	y	Mean Deviation.
	m	m	m
Nov. 13	−0·043	−0·017	0·025
14	−0·044	+0·003	0·017
15	−0·008	+0·001	0·022

The unit is tan 45°=1=1 metre ; and the corresponding positions of the radiant are

	R.A.	Decl.	Mean Deviation.
	°	°	°
Nov. 13	147·4	+21·0	1·4
14	147 3	+22·2	1·0
15	149·5	+22·1	1·3

Note.—The R.A. of the radiant on November 14 has extremely little weight : it depends practically on three trails, two of which are observations of the same meteor, which may well have belonged to the subsidiary shower B. (See below.)

When the coordinates of the apparent radiants had been found, the curve of position of the displaced radiant was drawn for each night, and the perpendiculars from the proper points on these curves to the respective trails were measured. The mean value of the perpendicular is given under the heading "mean deviation," and affords a criterion of the accuracy of the selected observations.

10. *Subsidiary Showers.*—We obtained four meteors on the 13th and four on the 15th, which might be ascribed to a subsidiary radiant A. Of these one was very probably a true Leonid, and has been included in the previous discussion. It is of course impossible to correct for zenith attraction &c. in the absence of knowledge of the true orbit. A graphical determination, similar to the above, of the most probable radiant from the eight paths gave

R.A. 153°·5, Decl. +37°·0.

Denning gives in his General Catalogue several determinations of a radiant which agree with this :

CXVIII. μ *Ursids.*

No. 15	155°+35°,	Nov. 13–15,	1879, Perry.
16	154+41,	14–17,	1885, Denning.
17	154+37,	15,	1875, A. S. Herschel.
18	155+35,	15,	1896, A. S. Herschel and Corder.

There were also five meteors on the 15th which might be ascribed to a radiant B. Of these, one was very likely a true

Leonid. The trails were not well situated for an accurate determination of the radiant point. It is approximately

R.A. 146°·7, Decl. +7°·4,

which is quite near the radiant given in the General Catalogue as

CXII. *o Leonids.*

No. 13 146° + 8°, 1891 Nov., Corder.

11. An attempt was made to photograph the trails with a 5-inch portrait lens on the Northumberland Equatorial. Only one trail was secured, on November 15, of a bright meteor nearly end on. Measurement of this trail is deferred until the arrival of our new measuring machine.

12. The method of Schiaparelli used here was adopted after a trial of several, because it seemed to combine quite admirably simplicity with rigour ; and this note must be regarded as the account of an attempt to prepare and gain experience for the future, rather than as the presentation of results of observation of much weight in themselves.

Cambridge Observatory:
1900 *March* 26.

The Equatorial Current of Jupiter in 1898.

By A. Stanley Williams.

The very striking appearance of the great Red Spot in the year 1879 gave an immense impetus to the study of the planet *Jupiter*, particularly as regards the investigation of the motions of the various spots and markings ; and as a result of this impetus we have available at the present time the results of researches extending over a period of more than twenty years. We are consequently now in a position to commence the discussion of certain questions having an important connection with the physical condition of the planet in a more satisfactory and intelligent manner than was before possible.

One of the most important of these questions is that connected with the changes which have been found to occur from time to time in the motions or velocities of certain spots and surface currents on the planet. Valuable papers on the changes in the motion of the Red Spot have already been published recently by Mr. W. F. Denning and Dr. O. Lohse,* and the changes which have happened, and are happening, in the velocity of the great equatorial current form a subject of perhaps not inferior importance. With regard to this latter subject, the

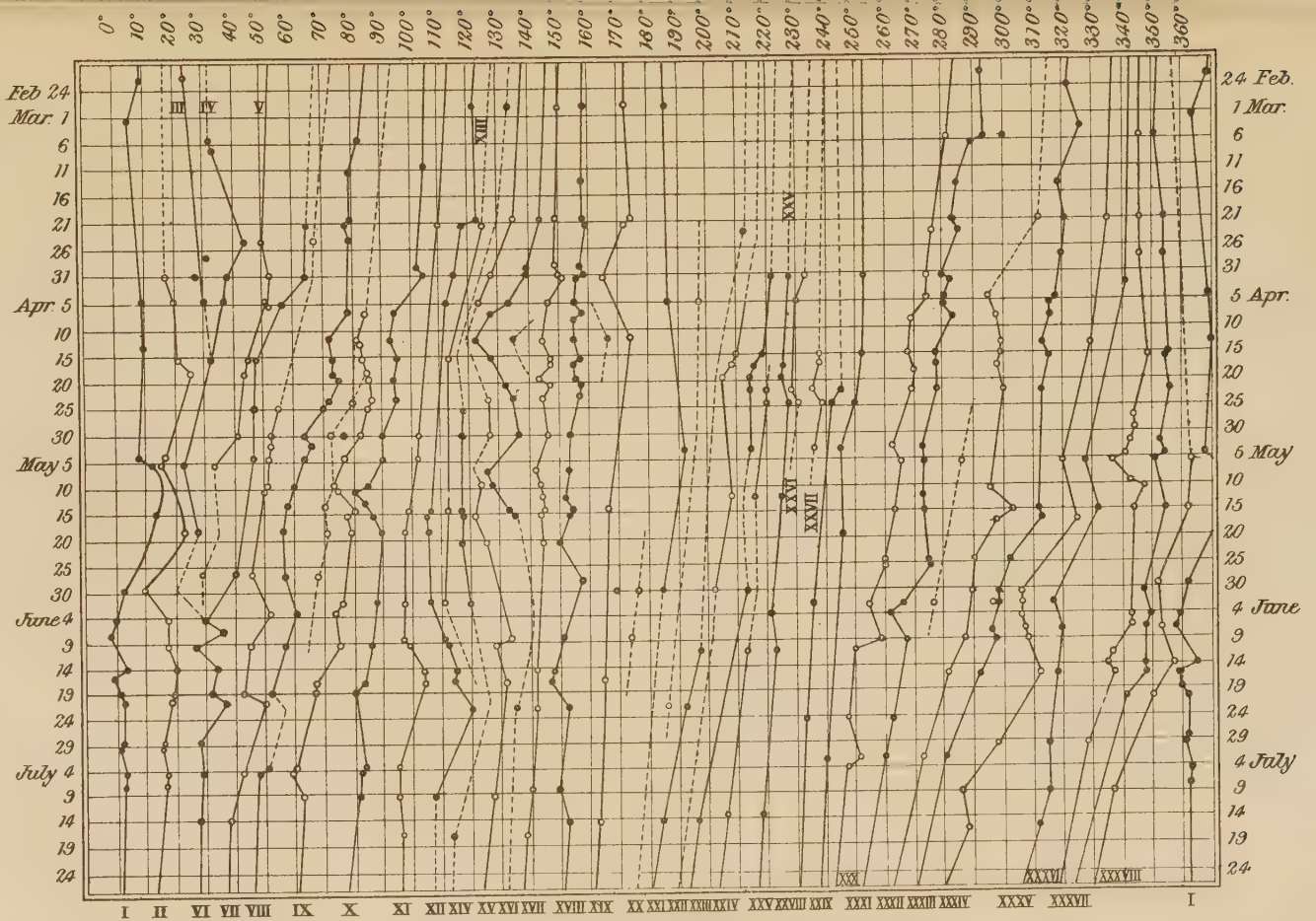
* See *Astr. Nach.* No. 3490, and *M. N.*, vol. lix. p. 574.

experience of the past twenty years shows, that, for the purpose of investigating the periodical or secular changes in the velocities of the various surface currents of *Jupiter*, it is very essential that the necessary data should be based upon all the available observations, so that the final results shall be as *definitive* as possible. The number of spots employed in the different determinations of velocity should be as great as possible, in order to avoid the local differences in the rate of motion which are found to affect individual spots; and the observations of each spot should extend over as long a period as possible, in order to eliminate the temporary variations which occur in the motions of most spots. Finally, the observations themselves should be numerous, in order that there may be no uncertainty with regard to correct identification. This last item is a very important one, as certain discordant results in the past must certainly be ascribed to incorrect identification.

A determination of the motions of the various extra-equatorial currents of *Jupiter* in the year 1898, based on the principles stated above, by the Rev. T. E. R. Phillips, has been published in the *Monthly Notices*, vol. lix. p. 79; and a similar one for the year 1899 in vol. lx. p. 210. The present paper contains the result of a similar definitive determination of the rotation period of the equatorial current in the year 1898, based likewise upon all the available observations. These observations are fairly numerous, the total number being 716, and 687 of these were made use of. The remaining twenty-nine observations relate to a few spots which were not sufficiently well observed for the purpose in view.

The method employed by Mr. Phillips of showing the observations in the form of charts is not so applicable to the present case, partly because of the numerous temporary changes or shifts in position of the individual spots, and partly on account of the difficulty that would arise from overcrowding. On the other hand, it is absolutely necessary that the observations should be published in some form or other, so as to enable other investigators to check, and if necessary to re-discuss, the results, and in particular to enable others to check the correct identification of the spots, upon which everything depends. I have, therefore, added at the end of this paper a complete list of the observed positions of the spots in as simple a form as possible.

The rotation periods of the spots were derived in the following manner. The observations were first plotted upon a chart similar to that in Plate 13, but on a larger scale, and with the difference that the whole of the observations were separately marked, not the mean values only. A thread was then stretched across the paper so as to lie as evenly as possible through the dots representing the observations of a spot. Two or three observations were then chosen near the beginning of the period of observation, and a similar number near the end, in such a manner that by comparison of these observations a rotation



Motions of the Equatorial Current of Jupiter in 1898.

period of the spot would be given corresponding as nearly as possible with that represented by the thread. This method was rendered necessary by the remarkable minor changes or wanderings in position of the equatorial spots, which wanderings will be very noticeable on reference to Plate 13. The observations which were chosen in this manner for computing the rotation periods are marked with an asterisk in Table II., but it should be clearly understood that they have usually been so selected as representing the whole body of observations, or the average motions of the spots, and not from any special significance or value of their own. Sometimes this method could not be adopted in its entirety, owing to the small number or peculiar grouping of the observations, and in such cases the nearest approach to it that was possible under the circumstances was made. On account of the wanderings of the spots being so considerable, I have not thought it necessary to add a column giving the residuals according to the adopted rotation periods of the spots, as the nature of these will be better gathered from the diagram, Plate 13.

In Table I. below will be found the concluded rotation periods of the spots, thirty-eight in number, derived in the above manner. The first column gives the number of the spot; the second, the rotation period; the third, the mean date to which such period refers; the fourth, the number of rotations performed between the first and last observations; and the fifth, the number of observations.

TABLE I.

Rotation Periods of the Spots.

Spot.	Rot. Per. h m s	Date.	No. of Rotations.	No. of Obs.
I.	9 50 27·9	1898·36	385	26
II.	28·6	·32	409	27
III.	37·4	·20	100	5
IV.	25·5	·27	180	9
V.	19·9	·22	309	10
VI.	15·2	·37	278	23
VII.	21·6	·37	273	16
VIII.	19·0	·34	297	34
IX.	18·6	·39	229	35
X.	21·2	·35	297	40
XI.	25·0	·38	285	21
XII.	27·1	·34	324	29
XIII.	21·4	·31	173	5
XIV.	24·6	·35	341	10
XV.	29·3	·36	273	14

Spot.	Rot. Per. h m s	Date.	No. of Rotations.	No. of Obs.
XVI.	29·3	·34	229	18
XVII.	26·7	·35	341	38
XVIII.	27·5	·34	336	48
XIX.	26·6	·34	336	9
XX.	29·4	·23	314	5
XXI.	20·8	·37	278	5
XXII.	27·4	·34	110	7
XXIII.	20·2	·39	251	12
XXIV.	22·8	·41	200	6
XXV.	26·5	·39	251	8
XXVI.	27·9	·14	299	6
XXVII.	23·0	·30	44	6
XXVIII.	24·1	·39	156	4
XXIX.	24·3	·37	224	6
XXX.	19·6	·33	290	32
XXXI.	20·6	·32	319	38
XXXII.	17·5	·36	251	20
XXXIII.	17·8	·32	312	29
XXXIV.	15·6	·38	285	16
XXXV.	18·6	·39	256	12
XXXVI.	25·4	·33	285	27
XXXVII.	27·8	·31	251	24
XXXVIII.	9 50 21·2	1898·40	112	7

Giving all the above results equal weight with the exception of spots IV., XIII., XXI., XXII., and XXVIII., which were given $\frac{1}{2}$ weight; and spots III., XXVII., and XXXVIII., which were given $\frac{1}{4}$ weight, the finally concluded period of rotation of the equatorial current for the mean date 1898·34 is

$9^h\ 50^m\ 24^s{\cdot}0$ (from 38 spots).

The above spots were all situated on or close to the north edge of the south equatorial belt. For comparison with the above value we have the following results derived by several observers from their own observations alone :—

W. F. Denning : $9^h\ 50^m\ 23^s{\cdot}6$ (23 spots), *Monthly Notices*, vol. lviii. p. 481.

W. J. Hall : $9^h\ 50^m\ 33^s{\cdot}2$ (9 spots), *Memoirs B.A.A.*, vol. vii. p. 91.

T. E. R. Phillips : $9^h\ 50^m\ 24^s{\cdot}2$ (19 spots), *Ibid.* vol. vii. p. 89.

It should be mentioned that my identifications agree with those of Mr. Denning from his own observations with a few unimportant exceptions. From the close accordance between the results of Mr. Denning and Mr. Phillips* and my own, it appears that the mean rotation period of the current can be determined with satisfactory accuracy, notwithstanding the very striking wanderings of individual spots or groups of spots, and in spite of an occasional observation being wrongly identified, provided that both observations and spots are sufficiently numerous, and that the former extend over a considerable period of time.

It is quite possible that a few of my identifications may be at fault in the present instance, and in fact by referring to Plate 13 it will be evident that alternative identifications are possible in several cases. Nevertheless it is quite certain that no serious or even appreciable difference would be produced in the final result by the employment of any such alternative identifications. Good drawings or diagrams of the markings are often a material help in deciding doubtful cases, but unfortunately they are not always available.

Referring again to Plate 13,† in which the dark spots are represented by dots and the bright ones by circles, there are several interesting conclusions that may be drawn. Thus—

(*a*) There is a distinct tendency towards a collection of the spots into groups having slightly different rotation periods, and analogous to the state of things described by Mr. Phillips as existing in the north tropical current in 1899 (*Monthly Notices*, vol. lx. p. 214 ; and Plate 6), but not so well marked.

(*b*) The curious wanderings in position of nearly all the spots. These wanderings are undoubtedly real in most cases, and due to actual changes or shifts in position of the spots. They are on much too large a scale to be ascribed to errors of observation, and moreover some of the widest departures from uniform motion are supported by the independent observations of several different observers.

(*c*) The wanderings of one spot are generally synchronous with similar wanderings on the part of adjacent spots. This would seem to indicate as the cause some local disturbance affecting comparatively small regions of the planet.‡ It is note-

* Mr. Hall's observations are in excellent agreement with the others, and his mean period differs so considerably only because in several cases his observations happened to have been made when the motions of the spots were unusually slow. Spot XII., for instance, was observed between June 10 and June 17, and it will be seen from Plate 13 that the motion of this spot was abnormally slow at that time. The effect of these temporary variations in motion is practically eliminated if the observations extend over a period of several months.

† The motion of the red spot would be represented on this diagram by a straight line very nearly at right angles to the direction of motion of the equatorial spots.

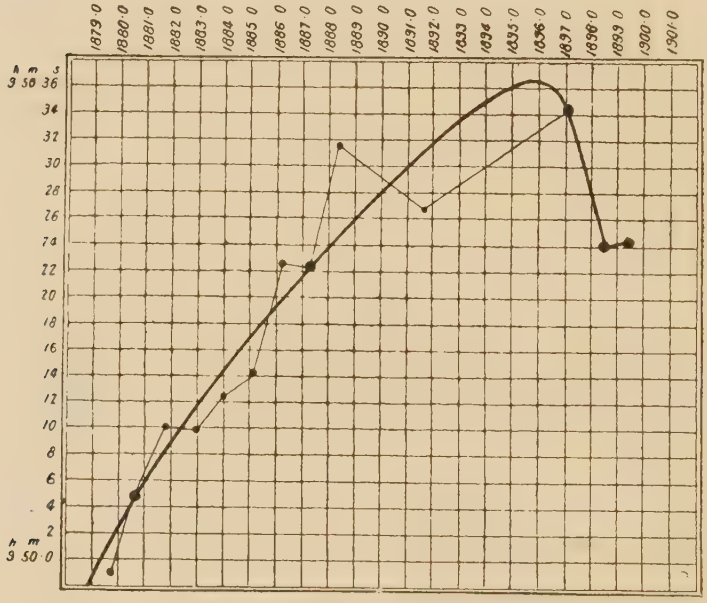
‡ In 1888, however, a remarkable disturbance of the same kind occurred which affected the spots over at least 250° of longitude.

worthy that in some cases, where several adjacent spots were affected, the wanderings of the spots grow less and less according as such spots were situated farther and farther away from the apparent centre of the local disturbance.

(*d*) Connected perhaps with these local disturbances is the tendency for some spots to subdivide, and again later on to reunite. Spot IX., for instance, split into two spots about April 15, which spots had reunited on May 4, whilst later on there was again a division into two.

(*e*) The manner in which spots III., IV., and V. either died out, were squeezed out, or else coalesced with adjacent spots seems worthy of note.

(*f*) The importance of having many observations of many spots covering a considerable period of time in order to satisfactorily determine the velocity of the equatorial current at any time.



The adjoining little diagram will show the present position with regard to the changes in the velocity of the equatorial current. The abscissæ represent time, and the ordinates rotation period or velocity.* The data prior to 1898 have been taken from *Monthly Notices*, vol. lviii. p. 14. The value for 1899 is the mean of the rotation periods derived by Mr. Denning and Mr. Phillips from their own observations. The large dots represent

* A change of 30ˢ in the rotation period is equivalent to an actual change of 22 miles (35 kilometres) an hour in the velocity of the current.

good determinations, depending upon a large number of spots. The small dots represent results based mostly on single spots. The 1880 result, resting as it does upon two spots and on several independent computations of rotation period, has been marked by a medium-sized dot. The thick black line shows the changes that have occurred in the velocity of the current during the last 21 years. The rotation period increased from $9^h\ 49^m\ 59^s$ in 1879 to a maximum of about $9^h\ 50^m\ 36^s$ in 1896, and from thence has diminished at a rather more rapid rate to 1898, when a distinct, though probably only temporary, check occurred. The form of the curve with this probably temporary check somewhat recalls the form of light curve of some variable stars, and also the curve of sunspot frequency between 1869 and 1872, as given in the diagram on p. 125 of Miss A. M. Clerke's *System of the Stars*, except that in the present case the descending curve is more abrupt than the ascending one. The velocity curve of the equatorial current also resembles closely in form the velocity curve of the Red Spot about the years 1854 61, as given in Mr. Denning's diagram in the *Monthly Notices*, vol. lix. p. 580. It is too early yet to enter into the question of periodicity; but, assuming the changes in velocity to be periodical, the period would seem to be a long one—probably at least 50 years, and possibly 100 or even more in length.

In Table II. the first column contains the date, the second the longitude of the spot according to "System I." of Mr. Crommelin's Ephemeris, and the third column a reference to the observer—namely:

B.=L. Brenner, Lussinpiccolo.
Bh.=D. Booth, Leeds.
D.=W. F. Denning, Bristol.
G.=J. Gledhill, Halifax.
H.=W. J. Hall, Nantwich.
M.=H. MacEwen, Glasgow.
P.=T. E. R. Phillips, Yeovil.
W.=A. S. Williams, Hove.

The longitudes were all derived from eye-estimates of the transits across the central meridian of the disc, with the exception of some of those due to Mr. Brenner, where the transits were taken across a micrometer wire bisecting the disc.

Observations marked with a * were used for computing the rotation periods of the spots. Those marked with a † were either noted as being unsatisfactory or approximate at the time, or else are based only on "estimated transits." A few apparently discordant positions are bracketed.

TABLE II.

Observations of Equatorial Spots.

Dark Spot I.

1898.	λ	Obs.	1898.	λ	Obs.
Feb. 22	8°8*	H.	June 14	(355°7)	G.
Mar. 2	3·8*	G.		4·2	M.
Apr. 4	8·7	W.	16	358·8	P.
	9·9*	H.	19	0·7	D.
13	9·7	W.	21	0·3†	P.
May 4	7·6	,,		2·9	M.
6	12·2	,,	28	0·3	D.
15	13 8	M.		2·7†	P.
29	1·4	,,	30	0·9	,,
June 5	359·7	P.	July 5	2·7*	D.
	0·4†	M.	7	356·3†	M.
7	358·0	,,		2·0*	D.
12	(354·5)	D.	30	359·6*	,,

White Spot II.

Jan. 20	22·1*	B.	June 5	17·5	W.
Mar. 31	16·7	M.		17·4	P.
Apr. 4	19·0*	W.	7	(8·4)	M.
	19·0*	Bh.	10	15·7	D.
	20·3	P.	14	18·9†	P.
16	20·4	Bh.		20·7	M.
18	24·5	P.	19	18·9*	D.
May 4	15·5	W.	21	18·2	M.
6	14·0	P.	28	14·9*	D.
18	20·8	D.		15·9*	P.
	21·3	G.	30	14·3*	,,
	24·3	P.	July 5	16·0*	D.
29	9·9	M.	7	16·4*	M.
June 5	13·8†	,,			

Dark Spot III.

Feb. 22	22·8*	G.	Mar. 31	27·7	M.
Mar. 28	30·7	P.	Apr. 4	30·3*	W.
31	26 0†	W.			

Dark Spot IV.

1898.	λ	Obs.	1898.	λ	Obs.
Mar. 5	31°3*	W.	Apr. 16	32°6	Bh.
8	32·6*	H.	May 6	22·6*	W.
24	43·6	M.	18	26·9*	D.
31	38·2†	W.	29	29·4†	M.
Apr. 4	34·9	H.			

White Spot V.

Jan. 20	59·9*	B.	Apr. 16	45·8	W.
Mar. 24	49·7	M.	18	43·4	P.
31	52·2	W.	30	41·1	,,
Apr. 4	50·7	,,	May 6	32·4*	W.
5	52·0†	M.	27	29·3*	,,

Dark Spot VI.

Mar. 22	66·4*	W.	June 10	26·7†	P.
31	64·4*	,,		27·3	D.
Apr. 5	56·3†	M.	14	34·1	M.
16	47·5	H.	19	30·2	P.
25	47·1	P.		33·6	D.
May 4	47·2	H.	21	35·8	M.
13	31·3	M.	28	28·4	D.
27	32·9†	,,	July 5	27·2*	P.
	39·6	W.		31·5*	D.
June 5	29·7†	,,	7	(39·0)	M.
	30·9†	M.	14	28·2*	,,
7	36·5	,,			

White Spot VII.

Mar. 24	67·4*	M.	May 11	50·0	P.
Apr. 25	55·6*	P.	27	43·9	M.
30	50·2†*	W.	June 3	51·4	W.
	55·1*	D.	10	43·8	P.
May 2	51·8	P.	19	43·0	,,
4	50·2	W.	21	50·5	M.
	52·1	P.	July 5	41·9†*	P.
9	50·8†	W.	14	38·6*	M.

Dark Spot VIII.

Mar. 5	81·4*	W.	Mar. 20	79·0*	H.
12	78·8*	G.	22	75·9*	D.

1898.	λ	Obs.	1898.	λ	Obs.
Mar. 22	78°·0*	W.	Apr. 30	63°·6	W.
24	78·9	M.		64·3	D.
Apr. 7	78·1	D.	May 2	65·8†	P.
12	71·8	M.	4	64·0	,,
16	71·0	Bh.	9	59·3	W.
	70·9	D.	13	56·9	M.
	70·8	W.	18	54·8†	,,
	76·3	P.	27	57·3	,,
	76·4	H.	June 3	60·6	W.
18	73·3	P.	10	57·2	D.
19	75·0	,,	19	51·3*	,,
23	71·8	W.		52·2*	P.
25	68·4	P.	July 3	50·8*	D.
	72·1	H.	5	48·5*	,,
30	63·1	P.	14	(56·9†)	M.
		White Spot IX.			
Apr. 7	83·6*	D.	May 11	73·7	P.
12	81·6	M.	14	79·5	D.
	81·1	P.	16	74·8	,,
13	81·9†	W.		78·4	P.
16	79·4*	D.	18	78·6	,,
	81·9*	Bh.		79·3	D.
	82·9*	P.	June 1	76·9†	P.
	86·1*	W.	3	74·0†	W.
18	83·6†	P.	10	73·0	P.
19	84·3*	,,		76·7	D.
	86·1*	D.	17	67·7	,,
23	86·9	W.	19	67·4	P.
25	84·9	P.	July 3	57·6*	D.
30	81·3	W.		62·0†*	P.
	82·6†	P.	5	58·3*	D.
May 4	77·1	,,		60·8†*	P.
9	72·7	W.	10	62·5*	D.
	72·8	B.			
		Dark Spot X.			
Mar. 10	105·7*	G.	Mar. 29	103·7*	W.
13	110·0†	M.	31	105·3*	,,
29	101·6*	P.	Apr. 7	94·0	D.

1898.	λ °	Obs.	1898.	λ °	Obs.
Apr. 12	92·5	M.	May 18	87·2	M.
16	94·2	D.		92·0	P.
	96·6	P.	June 1	87·6	P.
	97·7	W.		88·0†	W.
19	92·8	P.	10	85·2	P.
	94·3	D.		87·1	D.
23	92·9	,,		84·6	G.
	96·3	W.	17	79·7	,,
30	85·0	D.		82·7†	M.
	89·3	P.		84·2	D.
	90·1	W.	19	79·6	P.
May 4	90·5	P.	July 3	82·2*	,,
9	84·6†	W.		83·8*	D.
11	80·4	P.	5	81·5*	P.
13	83·1	M.	10	78·9†	
16	86·4	D.		80·7*	D.
	86·9	P.			

White Spot XI.

Mar. 22	110 0*	P.	June 10	96·5	D.
Apr. 30	102·1	,,		101·7	P.
	103·8	W.	15	104·5†	P.
May 4	102·1†	P.	17	101·0	M.
14	98·9	,,		105·2	P.
18	(91 4)	G.		104·9	D.
	98·1	P.	July 3	94·7	,,
	97·5	M.	10	91·1†	M.
June 1	97·1	P.		96 6*	D.
	99·0	W.	17	95·8*	,,
8	96·7†	M.			

Dark Spot XII.

Feb. 27	121·9*	W.	May 14	108·0	P.
Mar. 20	123·1†	,,	16	105·2	D.
22	116·8*	D.		105·2	W.
	118·6*	P.		108·9	P.
31	115·6	W.	18	105·4	,,
Apr. 5	112·8	,,		107·3	M.
May 14	106·9	D.	June 1	102 6†	P.

1898.	λ	Obs.	1898.	λ	Obs.
June 1	108°·2	W.	June 17	113°·7*	P.
8	110·7	M.		115·0*	G.
10	110·8	G.		116·9*	M.
	112·1	P.		118·1†*	H.
	114·4†	H.	22	119·8	D.
15	115·5	P.	July 10	105·8*	D.
	116·9	G.		110·0*	M.
17	112·2*	D.			
		White Spot XIII.			
Mar. 22	122·9*	D.	May 14	112·3*	P.
	126·5*	P.	June 1	111·1*	,,
Apr. 16	111·8	W.			
		Dark Spot XIV.			
Feb. 27	132·8*	W.	May 16	117·4†	M.
Apr. 26	118·4	P.	21	116·6	P.
30	117·3	,,	June 1	120·3†*	,,
	117·8	W.		120·3†*	W.
May 14	116·0†	P.	July 17	113·4*	D.
		White Spot XV.			
Mar. 20	134·1*	W.	May 9	123·3	W.
31	127·8*	,,	16	121·1	,,
Apr. 5	123·2	,,	21	126·4	P.
23	124·5	,,	June 8	133·9	M.
	127·8	P.	10	128·5*	P.
30	126·5	,,	17	132·1*	M.
	128·2	W.	July 10	127·0*	,,
		Dark Spot XVI.			
Mar. 20	143·8*	W.	Apr. 23	134·5	P.
29	139·7*	,,	30	136·1	W.
31	139·4*	,,		138·7†	P.
Apr. 5	133·6*	,,	May 7	124·4	W.
7	127·5*	D.	9	127·6	,,
12	121·8	M.	14	132·5†	,,
16	127·7	W.	16	130·8	,,
21	132·4	,,		139·4	M.
23	133·1	,,	June 22	135·1†*	P.

White Spot XVII.

1898.	λ	Obs.	1898.	λ	Obs.
	°			°	
Feb. 27	150·5*	W.	Apr. 23	144·1	W.
Mar. 20	146·6*	P.	30	146·0†	P.
	151·1*	W.		145·9	W.
29	146·1*	P.	May 7	141·5	,,
	150·8*	W.	9	142·8†	,,
31	150·4	,,	12	141·4	D.
Apr. 1	150·9	M.		144·4	P.
5	145·3	P.	14	143·4	,,
	146·4	W.		143·4	D.
12	138·9	M.		146·6	W.
	144·5	P.	16	141·8	M.
	145·0	W.		144·2	W.
	147·4	D.		146·1	P.
16	146·6	W.	21	143·5	,,
17	146·6	D.	June 15	141·1	,,
19	142·8	P.	22	140·0*	D.
	143·4	D.		142·4*	P.
21	147·0	W.	July 8	140·0*	,,
23	143·6	P.	17	138·5*	D.

Dark Spot XVIII.

Feb. 27	158·4*	W.	Apr. 16	157·6	W.
Mar. 13	157·7	P.	17	155·2	D.
20	155·8*	,,		157·0	M.
	160·9*	W.	19	154·8	H.
22	159·1	,,		154·1	P.
29	157·2	,,		156·8	D.
31	158·6	,,	21	157·7	W.
Apr. 1	155·2	M.	23	157·0	,,
	155·8	D.	30	153·2	,,
5	153·2	P.		153·3	P.
	155·5	W.	May 7	152·3	W.
7	156·8	D.	12	150·5	D.
8	154·3	,,		152·3	P.
12	152·4†	H.	14	152·6†	,,
	152·4	P.		154·5	D.
	155·3	D.		154·5	W.
	156·2	W.	16	152·8	P.

1898.	λ	Obs.	1898.	λ	Obs.
May 16	154°0	M.	June 22	150°6*	P.
21	149·6	P.		152·2*	D.
28	156·8	D.	July 8	147·9*	M.
30	(142·8†)	M.		151·0†*	P.
June 8	150·9	,,	10	142·9†	M.
15	147·8	P.	15	152·5*	D.
17	146·7	M.		152·8*	P.

White Spot XIX.

Feb. 27	172·5*	W.	May 14	167·3	W.
Mar. 20	173·7*	,,	30	(154·3)	M.
22	171·2*	,,	June 17	163·8†	,,
Apr. 1	165·0	M.	July 15	161·7*	D.
12	173·6	Bh.			

Dark Spot XX.

Jan. 21	186·7*	B.	May 3	192·0	H.
Feb. 27	185·3*	W.	30	184·2*	M.
Apr. 5	186·1	P.			

Dark Spot XXI.

Mar. 23	213·2*	M.	June 22	192·6*	D.
June 11	194·7*	P.	July 15	183·6*	,,
	199·8*	D.			

White Spot XXII.

Apr. 15	209·6*	D.	Apr. 19	205·0*	W.
17	207·6*	P.	May 12	207·9*	D.
	209·4*	D.	30	201·9*	M.
	209·3*	W.			

Dark Spot XXIII.

Jan. 21	(222·8)	B.	Apr. 19	214·1	W.
Apr. 1	221·0*	P.	22	212·8	M.
15	218·8	D.		217·6	D.
17	215·5*	,,	May 3	215·1	W.
	216·7*	P.	30	212·9	M.
	217·2*	W.	July 13	195·9*	D.

White Spot XXIV.

1898.	λ	Obs.	1898.	λ	Obs.
	°			°	
Apr. 22	220·1*	M.	June 11	210·8	D.
24	219·8*	D.		213·6	P.
May 12	213·9	P.	July 13	205·8*	D.

Dark Spot XXV.

Apr. 1	227·2†*	H.	May 12	223·7	D.
17	224·6*	W.	June 4	220·9†	M.
19	223·9*	,,	11	223·0	D.
24	228·1*	H.	July 13	218·5*	,,

White Spot XXVI.

1897. Dec. 22	236·3*	P.	Apr. 5	230·5*	W.
1898. Jan. 21	236·2*	B.	22	228·0	M.
Apr. 1	232·9*	P.	24	230·8*	D.

White Spot XXVII.

Apr. 15	237·6*	D.	Apr. 22	234·1	D.
17	236·3*	P.	24	238·8†	W.
	238·7*	W.	May 3	234·6*	,,

Dark Spot XXVIII.

Apr. 22	243·9*	M.	June 2	235·5†	M.
24	240·6*	D.	25	233·2*	D.

Dark Spot XXIX.

Apr. 1	253·1*	H.	May 3	243·7	W.
15	252·9	W.	19	246·2	M.
24	249·8*	,,	July 2	240·1*	D.

White Spot XXX.

1897. Dec. 20	(291·5)	P.	Apr. 8	269·0	W.
1898. Mar. 5	280·9*†	W.	15	267·5	P.
23	276·7*	P.		268·7	D.
30	(265·0)	M.		268·7	W.
Apr. 1	274·1	P.	17	269·2	P.
4	(266·2†)	M.		270·4	D.
	272·8	D.	22	264·9†	W.
	(265·5†)	W.		268·8	D.

1898.	λ	Obs.	1898.	λ	Obs.
May 3	(252°3†)	W.	June 2	(248°3†)	M.
	261·4	,,		254·7	W.
6	265·5	D.		256·2†	P.
	265·5	G.	9	258·4*	D.
15	262·3	D.	11	249·6	P.
	263·8	W.	25	248·5*	D.
24	260·1	,,	July 2	251·1*	,,
26	260·1	M.	4	246·8†	M.
		Dark Spot XXXI.			
Feb. 21	291·7*	G.	Apr. 17	277·1	P.
Mar. 5	293·1	W.		278·9	D.
7	289·3*	G.	22	277·7	W.
14	282·7*	D.		277·9	D.
	283·9*	H.	May 3	271·8	W.
	285·1*	P.	6	272·8	D.
21	280·4	H.	12	272·4	P.
	283·9	D.	15	272·7	D.
	286·2	W.		273·6	W.
23	284·6	P.	24	274·2	,,
Apr. 1	279·6	,,	26	275·4	M.
2	282·1†	M.	June 2	261·1	,,
4	278·4	,,		267·2	W.
	283·8	D.		269·9	P.
6	280·7	W.	4	261·4	M.
8	282·4	,,	9	268·1	D.
15	276·6	P.		262·3†	P.
	277·9	D.	25	261·9*	D.
	279·7	W.	July 2	260·3*	,,
		White Spot XXXII.			
Mar. 21	313·1*	W.	May 11	295·3	G.
	314·6*	P.	15	303·2	D.
Apr. 4	295·4	M.	17	296·7	M.
8	297·1*	W.	24	290·6	W.
13	298·8*	,,	31	289·6	P.
	300·0†*	P.	June 2	295·8	M.
15	297·4	,,	9	287·3	P.
	300·4	W.	16	281·4*	,,
17	298·0	,,		282·0*	D.
22	300·3	,,	July 2	273·1*	,,

Dark Spot XXXIII.

1898.	λ	Obs.	1898.	λ	Obs.
Feb. 24	321°·6*	H.	May 15	310°·1†	W.
Mar. 3	326·0*	,,		310·5†	P.
14	318·7	D.		312·3	D.
21	319·3	H.	17	312·5	M.
	320·5	D.	24	301·6	W.
	321·0	W.	31	298·2	P.
	324·3	P.	June 2	297·1†	,,
28	319·9	,,		300·7	M.
Apr. 4	318·0†	M.	7	294·8	D.
6	314·9†	P.	9	297·1*	P.
8	315·4	W.	16	290·5*	,,
13	313·4	P.		293·0*	D.
	313·4	W.	July 2	280·1*	P.
16	315·1†	M.		282·2*	D.
22	311·8	W.			

White Spot XXXIV.

Mar. 21	335·1*	W.	June 7	304·6	D.
Apr. 13	329·4*	,,		309·9	W.
May 6	319·8	,,	9	308·7	P.
17	324·7	M.	16	311·9*	,,
31	306·1	P.	30	298·1*	D.
June 2	305·6	,,	July 9	285·1	,,
5	305·6	B.		294·0†	M.
7	303·8†	M.	16	288·7*	D.

Dark Spot XXXV.

Apr. 2	340·7*	M.	June 9	(328·2)	M.
May 6	328·4	W.	16	318·0	D.
15	331·8	M.	30	313·9*	,,
June 2	317·2†	,,	July 9	314·9*	,,
7	316·8	D.		315·4*	M.
	319·6	W.	16	310·7*	D.

White Spot XXXVI.

Mar. 5	344·3*	W.	Mar. 28	346·5	P.
21	345·0*	P.	Apr. 16	349·2	D.
	346·7*	W.	27	343·7	W.

1898.	λ	Obs.	1898.	λ	Obs
Apr. 29	343°8	P.	June 5	341°4	P.
May 2	341·7	,,		342·8	W.
4	341·4	,,	7	341·0	M.
6	334·4	D.		342·4	P.
	339·0	P.	12	336·2	D.
	339·3	W.	14	331·3†	M.
9	342·0	B.		334·4	P.
11	347·1	G.	16	336·9	,,
15	343·4	M.	30	322·5†	,,
	345·2	P.		329 8*	D.
31	(334·7)	,,			

Dark Spot XXXVII.

Mar. 5	350·4*	W.	May 15	355·3	P.
21	355·4*	P.	31	347·5	,,
	355·2*	W.	June 5	348·1	P.
28	353·8	P.		351·3	W.
Apr. 15	355·9	W.	7	347·1	M.
16	355·2	D.		348·8	P.
22	355·6	,,	12	(354·5)	D.
May 2	352·7†	P.	14	346·2*	M.
4	353·6	,,		349·0*	P.
6	350·8	,,		(355·7)	G.
	350·8	D.	16	347·8†*	P.
15	354·9	M.	21	341·0†	M.

White Spot XXXVIII.

May 6	3·7*	W.	June 14	357·0*	M.
15	2·3*	M.	21	350·2†*	,,
29	351·1†	,,	July 9	336·1†	,,
June 7	353·2	,,			

Unused Observations.

Mar. 21	10·0	P.	White	May 13	70·3	M.	White
Apr. 15	10·5	W.	,,	18	71·3	,,	,,
23	79·6	D.	,,	27	68·3	,,	,,
30	71·6	P.	,,	Apr. 12	132·6	H.	Dark
	72·8	D.	,,		134·3	W.	,,
	75·9	P.	Dark		135·8	M.	,,

1898.	λ	Obs.	Spot.	1898.	λ	Obs.	Spot.
Apr. 12	167°0	P.	Dark	May 8	279°3	G.	White
May 30	169·0	M.		15	282·7	W.	Dark
	176·3	„	White	June 2	277·0	M.	White
June 8	173·5	„	„		278·2	P.	„
Apr. 5	197·6	W.	„	Mar. 5	299·3	H.	Dark
June 22	185·1	D.	„		300·4	W.	„
Apr. 22	232·9	M.	Dark	June 7	328·2	M.	„
May 6	286·9	D.	White	May 31	334·7	P.	White
	287·4	P.	„				

Notes.—Spot I. The bracketed observations relate to the combined mass of I. and XXXVII.
Spot XXIII. It is doubtful if the first observation refers to this spot.
Spot XXX. There were two spots here close together, and the bracketed positions probably relate to the preceding spot. Both spots were observed on May 3.
Spot XXVII. The bracketed observations relate to the combined mass of I. and XXXVII.

Graphical Method for the Determination of the Local Times of Contact in a Solar Eclipse. By F. C. Penrose, D.C.L., F.R.S.

Having first obtained (also graphically) an approximate time for the middle of the eclipse which may be depended upon, if carefully done, within a minute of time, let the reader be supposed to be looking in a southerly direction at a perspective projection, showing the circumstances of the eclipse formed on a plane at right angles to the direction of the Sun and Moon. As he must necessarily be rather nearer to the Moon than the geocentric distance, the *distance of the picture* would be somewhat less than the geocentric distance, and her semi-diameter and the other lunar elements would be augmented ; but for convenience of calculation it is better to use the geocentric values, which would have the same relation to one another in projection, and to reduce the solar in inverse proportion. This need only be done to the semi-diameter, which is the only one of consequence.

In this projection the parallax which represents the observer's motion will be an arc of an ellipse dependent upon horizontal parallax and geocentric latitude ; and the soli-lunar motion, as the arc is so small, admits of being represented by a straight line.

This being premised, the elements for constructing a diagram to show the circumstances of totality may be thus found.

First, compare the arguments given for the Sun and for H.P. and the Moon's semi-diameter in the *Nautical Almanac* for the same day at noon (unless, owing to longitude or other considera-

tions, a midnight argument, or one for another noon would be nearer to the assumed time) with those given for the particular eclipse, and tabulate the differences ; then find from these the corrections required for the assumed time in simple proportion, giving for the assumed time the R.A. and declination of the Sun, the H.P. and the Moon's semi-diameter. Then find the hour angle, and with the geocentric latitude compute the values in the direction of R.A. and declination of the parallax, the tangent to the elliptic curve, and the extent of one minute's motion and the Sun's altitude, and from this compute the augmentation. We are now in a position to lay down on paper two straight lines, one representing the soli-lunar motion to be drawn through the place as above found for the solar and lunar centres, and the other representing the tangent to the parallactic curve drawn through the corresponding point of parallax. Mark on these lines the extent of one minute's motion, both previous to and subsequent to the assumed time, produced as might be required, and subdivided into scales of seconds of time.

It is now easy, if totality be possible, to find the points where the extremities of a radius $= S - s$ with its augmentation increment, will rest upon similar numbers of seconds on the soli-lunar and parallax scales, the western coincidence giving the second and the eastern the third contact.

Calculation of the times of 2nd and 3rd Contact for the Total Solar Eclipse at Ovar on 1900 *May* 28.

Latitude of Ovar $= \lambda = 40^\circ\ 51'$ N.

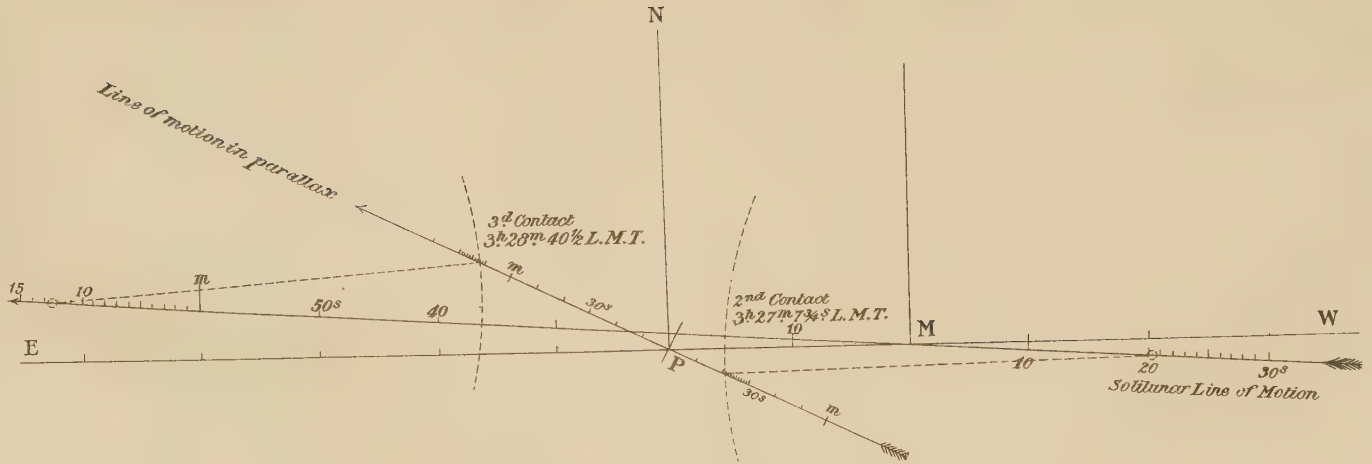
Geocentric Latitude $= l$ { $\log \rho \sin l = 9{\cdot}81330$; $\log \rho \cos l = 9{\cdot}87940$

Longitude of Ovar $= 34^m\ 32^s$ W.

Mid-totality at Ovar occurs at $4^h\ 2^m$ G.M.T. (approx.)

1900 May 28, $4^h\ 2^m$ G.M.T.

⊙'s R.A.	$= \alpha = 4^h\ 19^m\ 58^s{\cdot}33$.	Change in $1^m = 0^s{\cdot}178$
⊙'s Dec.	$= \delta = 21^\circ\ 27'\ 41''{\cdot}9$.	„ „ $= 0''{\cdot}405$
Hour Angle	$= t = 3^h\ 30^m\ 26^s{\cdot}45$ E.	
Altitude of ⊙	$= 41^\circ\ 49'{\cdot}5$	
☽'s R.A.	$= A = 4^h\ 22^m\ 28^s{\cdot}76$.	Change in $1^m = 2^s{\cdot}484$
☽'s Dec.	$= D = 21^\circ\ 53'\ 6''{\cdot}36$.	„ „ $= 2''{\cdot}529$
☽'s Hor. Par.	$= P = 58'\ 25''{\cdot}79$	$P - p = 58'\ 17''{\cdot}06$
⊙'s Hor. Par.	$= p = 8''{\cdot}73$	
☽'s Semi-diam.	$= S = 15'\ 55''{\cdot}30$	$S - s = 8''{\cdot}71$
⊙'s Semi-diam.	$= s = 15'\ 46''{\cdot}49$	



CIRCUMSTANCES OF THE TOTAL ECLIPSE AT OVAR
REDUCED GRAPHICALLY

The augmentation of S—s for Altitude 41° 49′·5 = 10″·80

∴ The augmented value of S—s = 19″·51

The Parallax in R.A. = (P—p) ρ cos l sin t

= 35′ 4″·75

The Parallax in Dec. = (P—p) (ρ sin l cos δ — ρ cos l sin δ cos t)

= 25′ 28″·69 (above the centre)

The Soli-lunar position in R.A. = (A—a) cos D

= 34′ 53″·85 (E. of Minor Axis of parallactic ellipse)

„ „ „ in Dec. = D—δ

= 25′ 24″·46.

To this 4″·20 must be added, on account of the lunar orbit, making the position 25′ 28″·66 above the centre.

The extent of motion of parallax in 1^m in R.A.

= (P—p) ρ cos l cos t Δt = 7″·02.

The extent in Dec. = (P—p) ρ cos l sin δ sin t Δt.

Therefore the tangent of the angle at the parallax point

= sin δ tan t = 25° 35′.

The Soli-lunar motion in R.A. in 1^m = (2^s·484—0^s·178) cos δ

= 32″·24

„ „ „ in Dec. in 1^m = 2″·529—0″·405

= 2″·124.

The diagram (Plate 14) is constructed from these elements : P is the parallax at 4^h 2^m and its line of motion is drawn. M is the Soli-lunar centre and its line of motion is drawn. The diagram shows that the second contact occurs 20$^s\frac{1}{4}$ before 4^h 2^m, and the third contact 1^m 12$^s\frac{1}{2}$ after it.

An Application of Projective Geometry to Binary Star Orbits.

By H. C. Plummer.

1. In the numerous methods which have been employed in the determination of the orbits of double stars, it is natural, on account of the comparatively coarse nature of the observations, that much use has been made of graphical devices. These for the most part are of the "trial and error" kind. T. N. Thiele * and J. M. Wilson,† however, have given direct geometrical constructions by which the relations between the apparent and the

* *A.N.* 1227. † *M.N.* xxxiii. p. 375.

real orbit are exhibited, and the former has made practical use of his method. It is my object here to deduce these relations from a consideration of the projective properties of the ellipse, and to show how the geometrical elements of the orbit, viz. i, Ω, λ, e, a, may be determined by a tolerably simple construction. It is, of course, impossible to use direct time measures in a method which is essentially geometrical. As in Savary's * first method, the necessary data are taken in the shape of five positions in the apparent orbit. Then the problem to be solved may be stated thus : Given five points and a certain fixed point, to find the orthogonal projection such that the corresponding five points will lie on an ellipse the focus of which projects into the fixed point. The solution takes the form of constructing the line of nodes, finding the inclination of the orbit, and laying down the five points corresponding to the apparent positions. The ruler and compasses alone are used in the process, and it is quite unnecessary to draw an ellipse.

2. It is convenient to consider in the first place a fundamental problem the solution of which will be required. This is to find the orthogonal projection by which two right angles project into two given overlapping angles contained by four lines which meet in a point. Let S be the point (Plate 15, fig. 1), and suppose that the lines intersect a transversal in AA′, BB′. On AA′, BB′ as diameters describe circles meeting in a point F. Then if F be rotated about AA′ out of the plane of the paper, the given figure may be considered as a projection on to the plane SAA′ from the point at infinity on the line SF as vertex. The projection is a parallel one, and is in addition orthogonal if SF be perpendicular to the plane SAA′. Hence SF must be perpendicular to AA′. Now if N is the foot of the perpendicular from F on AA′, $AN.NA'=NF^2=BN.NB'$, or N is the centre of the involution range determined by AA′, BB′. Hence SN and the line through S parallel to AA′ are a corresponding pair of the involution pencil S (AA′, BB′,...), since N being the centre of the range is the point corresponding to the point at infinity on AA′. Conversely if the transversal AA′ be drawn parallel to one line of the orthogonal pair in the involution pencil S (AA′, BB′ ..), the point F constructed as above will lie on the perpendicular from S to the transversal. Then when F is rotated about AA′ till FS is perpendicular to the plane SAA′, the projection is orthogonal, and we have the projection required, for the angles ASA′, BSB′ are the projections respectively of AFA′, BFB′, which being angles in semicircles are right angles. We thus have a simple method suggested for constructing the transversal or turning line AA′ through any fixed point C, which is as follows. Describe a circle on SC as diameter and let it cut the rays of the pencil S (AA′, BB′) in A_1, A_1', B_1, B_1'. Join OK, where K is the centre of the circle and O is the intersection of

* *Conn. des Temps*, 1830.

Fig. 1

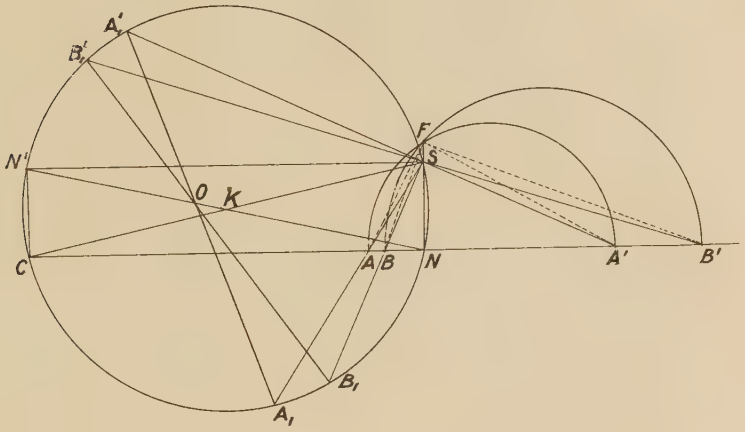
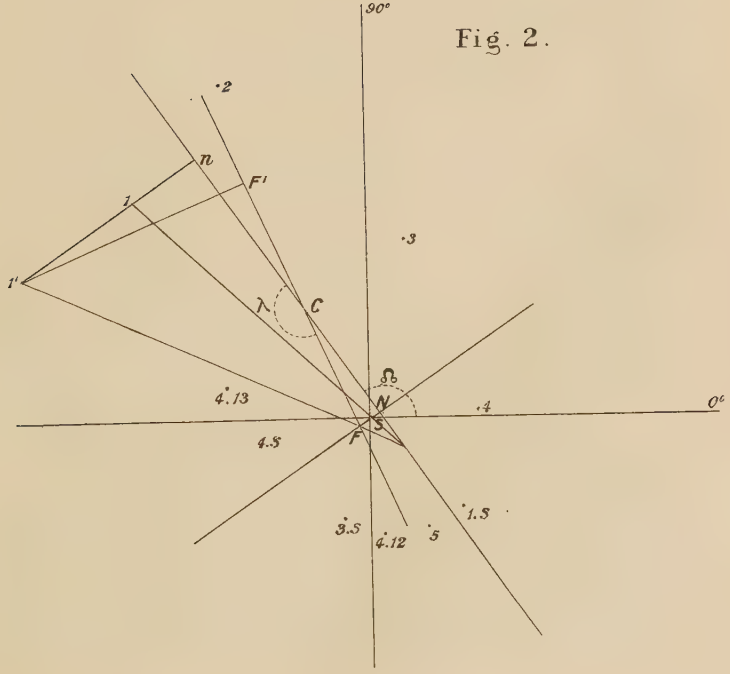


Fig. 2.



A_1A_1' and B_1B_1', and let OK meet the circle in NN′. Then SN, SN′ are orthogonal rays of the involution, since NN′ is a diameter and NN′, A_1A_1', B_1B_1' are concurrent chords. Also clearly CN, CN′ are parallel to SN′, SN respectively. Finally the choice between CN and CN′ as a transversal must be decided by the consideration that it must fall across the obtuse angle between SA and SA′, for otherwise the point F would lie nearer the turning line than S, and the orthogonal projection would become impossible.

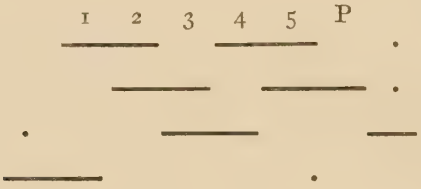
3. The general method of procedure is now obvious. Through S, the position of the principal star, two pairs of conjugate lines must be drawn. If then through C, the centre of the apparent ellipse, a line be drawn by the construction given at the end of § 2 parallel to one of the orthogonal pair of the involution of conjugate lines through S, this line is the turning line required, or the line of nodes. Then the point F is found as in § 2, and this when the plane FAA′ is rotated so that FS is perpendicular to the plane SAA′ projects orthogonally into the point S. Moreover, since the conjugate pairs of lines through S are the projections of orthogonal pairs through F, F is the focus of the ellipse which projects into the apparent orbit. As the line of nodes and the focus of the true orbit are now known, the problem in view has been virtually solved. If the method of Sir John Herschel has been followed as far as the drawing of the apparent ellipse, the centre C is known and pairs of conjugate lines may be constructed by drawing chords through S, constructing tangents to the ellipse at their extremities and joining S to the poles of the chords. The completion of the solution is then simple and rapid.

4. But the actual drawing of the apparent orbit is unnecessary and even objectionable. For it must be a more or less troublesome and unsatisfactory process, and besides the choice of five characteristic points should be not merely easier but also capable of at least equivalent accuracy. Hitherto observed distances have been utilised only in a minor degree in the calculation of orbits, having been long under the ban of Sir John Herschel's authority. Even at the time when this neglect may have been justified by the inferiority in the measures of this coordinate, Encke held other views as to their value. But now that greatly increased accuracy is attainable in this part of the observations, it seems permissible to place reliance on this material, and perfectly feasible to employ it for the purpose we have in view.

The five points will be denoted by the numbers 1, 2, 3, 4, 5 (Plate 15, fig. 2). Also the other extremity of the chord through 1 parallel to the line joining 2 and 3, for instance, will be denoted by the notation 1.23, while the other extremity of the chord through 1 and S will be denoted by 1.S. Now points such as 1.23 and 1.S can be easily found by the well known construction with the ruler only. Five of these points are required, two of the former type and three of the latter. The two will determine two pairs

of parallel chords, and will therefore give the centre of the ellipse as the intersection of the two diameters which bisect the parallel chords. The other three points give three chords which meet in S, and by taking these two at a time we obtain three quadrangles inscribed in the conic, for each of which S is a harmonic point. Thus, for instance, if the quadrangle 1, 2, 1.S, 2.S, be taken, and the lines joining 1, 2 and 1.S, 2.S, meet in Z, while the lines joining 1, 2.S and 2, 1.S meet in Z′, the pair of lines SZ, SZ′ are conjugate. Three pairs of conjugate lines can therefore be drawn, and as two only are required those may be chosen which can be constructed most easily.

5. The construction of the five additional points is an important part of the method, and as it is rather complicated I give the following plan which I have found a convenient aid in order to avoid confusion. Suppose that the point P is required in which a fixed line through 5 cuts the ellipse again. Then the following scheme may be useful :—



in which each line indicates that the points to be found vertically above it are to be joined, and which is to be taken line by line, and read thus : (1) join 1, 2 and 4, 5 ; these meet in a point (placed on the right) ; (2) join 2, 3 which meets the line 5P in a point (also placed on the right) ; (3) join 3, 4 and the two points of intersection ; these lines meet in a point (placed on the left) ; (4) join the latter point to 1, and this line intersects 5P in the point required. The scheme can be followed mentally on the figure before the construction is made. In this way it can be decided first whether the intersections will fall conveniently on the paper. If, as will often happen, they fall outside it, it will be better to alter the order of the first four points in the scheme. There will then be a new hexagon, and the Pascal line may be constructed more easily. For instance, if the intersection of 12 with 45 is near the centre of the paper, and the intersection of 23 with 5P lies beyond the edge, it is natural to start with the hexagon 2 1 3 4 5 P instead of 1 2 3 4 5 P. Such details will naturally occur, and are only mentioned here because they have considerable importance in practice.

6. For the sake of clearness it seems well to summarise the actual steps which have to be made, referring for greater definiteness to an actual case. The natural order will be :

(*a*) To select the characteristic positions and to plot the five places to a suitable scale.

(*b*) To construct the points 4.12 and 4.13, to draw the diameters bisecting the parallel chords, and so to find the centre C.

(*c*) To construct the points 1.S, 3.S, and 4.S, to complete the quadrangles 1, 4, 1.S, 4.S, and 3, 4, 3.S, 4.S, and by means of them to draw two pairs of conjugate lines through S.

(*d*) To construct, as explained in § 2, the orthogonal pair of the conjugate involution, and to draw through the centre the line of nodes.

(*e*) To find the point F as in § 2 ; this is the focus of the real orbit. Also it is evident that the inclination is given by

$$\cos i = \mathrm{SN}/\mathrm{FN}.$$

(*f*) To lay down the five positions in the real orbit, and to deduce the values of the elements a, e and λ. This will be next explained.

7. In the first place CF is the line of apsides, and CN is the line of nodes ; it follows that $\pi - \lambda$ is the angle FCN. As the relations between the planes of the apparent and real orbits have been already found, it is unnecessary to retain the distinction. In fact it is simpler to lay down the five real positions in the plane of the paper by considering them as in parallel homology with the apparent figure. The line of nodes CN is the axis of homology, the centre of homology is at infinity on a line at right angles to CN, and F and S are a pair of corresponding points. The point 1′ corresponding to 1 is then easily found, since 11′ is perpendicular to CN, and 1′F and 1S meet on CN. Similarly the homologues of the points 2, 3, 4, 5 can be laid down. Then if F′ be the second focus, five measures of a are available, viz. $\frac{1}{2}(1'\mathrm{F}+1'\mathrm{F}')$, &c. But $\mathrm{CF}=ae$, and so the eccentricity is found by dividing CF by the mean value of a. Thus all the geometrical elements of the orbit have been found, and finally the two remaining elements, the mean motion and the epoch, can be calculated at once from the dates of two observations, though of course better from more extensive data. It is to be remarked that the agreement in the values of a, found as above from the five points, is a measure of the correctness of the drawing, on which it forms a useful check. On the other hand, additional normal places may be laid down, and their homologues may be constructed. From these an additional set of values of a can be obtained. The agreement of these values among themselves, and with the former set, furnishes a criterion of the concordance of the observations involved, and of the accuracy of the assumption that the five adopted positions characterise the orbit.

8. Having now sketched a method of dealing with binary star orbits, it is interesting to consider the result of applying it to a particular system. In order best to test the practicability of the method and to judge the order of accuracy which it is capable of giving, I chose the star 70 *Ophiuchi*, because, apart from the

historic interest which the system possesses, and the fact that sufficient observations existed to make a fair trial possible, it has been made the subject of an exhaustive research by Professor Schur, and therefore its orbit is to be considered so far definitive as the refinements of rigorous calculation could render it. The five characteristic places were chosen at random, but so as to cover as large an arc as possible, though it was judged advisable to leave on one side the earlier observations of Sir W. Herschel and others. The following are taken from a list of normal places given by Dr. See * :—

No.	Date.	Pos. Ang.	Dist.
1	1830·57	136°·8	5″·58
2	1854·48	113·2	6·37
3	1877·60	77·4	3·23
4	1887·68	3·8	1·91
5	1895·64	296·1	2·14

These were plotted to the scale 1″=22 mm., and their relative positions are quite roughly indicated in fig. 2. The result of measuring the drawing was to give the following elements, against which I place Professor Schur's † elements for comparison :—

		Schur.
i	57° 40′	60°·08
☊	121 49	121·31
λ	167 2	168·3
a	4″·596	4″·60
e	·515	·4751

The value of a given above rests on a single measure of F1′+F′1′. This in itself is an indication that the above elements are really what might not unfairly be called a rough preliminary measurement, the apparent accuracy being altogether unexpected and surprising. They represent such results as may reasonably be attained in an hour's work after the five points have been selected and laid down.

9. It then became a matter of interest to calculate the epoch and the mean motion. Using the extreme places 1 and 5, we get these values :—

		Schur.
T	1895·445	1896·4661
P	86·8	88·3954

Instead of proceeding with these, which evidently rest on an insufficient basis, it seemed better to use additional places, and the following elements were adopted, though it must be under-

* *Ast. Jour.* 363. † *A.N.* 3220–1.

stood that they were not obtained, as they might have been, from a least squares solution :—

$$T=1895{\cdot}70, \quad P=88{\cdot}32, \quad a=4''{\cdot}495.$$

The following table exhibits the comparison between the places computed from these elements and the observed coordinates, which have been taken from Dr. See's paper already quoted, except the last three places depending solely on Mr. Maw's measures.*

Date.	Position Angle.	Distance.	C−O Angle.	C−O Distance.	Date.	Position Angle.	Distance.	C−O Angle.	C−O Distance.
	°	″	°	″		°	″	°	″
1830·57	136·8	5·58	−1·3	−0·27	1858·39	109·1	6·01	+0·3	+0·29
1831·58	135·1	5·68	−0·9	−0·18	1859·66	108·4	6·24	−0·3	−0·05
1832·62	133·4	5·75	−0·5	−0·09	1860·70	107·3	6·33	−0·2	−0·24
1833·42	132·8	6·14	−0·9	−0·37	1861·67	106·2	5·70	−0·1	+0·20
1834·55	130·8	6·04	−0·1	−0·12	1862·59	105·6	5·83	−0·4	+0·05
1835·60	130·7	6·11	−1·1	−0·06	1863·54	104·8	5·62	−0·6	+0·14
1836·52	128·9	6·34	−0·2	−0·20	1864·54	104·1	5·43	−1·0	+0·20
1837·64	127·9	6·45	−0·3	−0·19	1865·50	102·4	5·32	−0·5	+0·18
1838·59	126·6	6·64	0·0	−0·29	1866·43	101·2	5·31	−0·6	+0·06
1839·58	125·5	6·66	+0·2	−0·24	1867·50	99·6	5·18	−0·5	+0·03
1840·47	126·5	6·38	−1·7	+0·11	1868·65	98·6	4·90	−1·1	+0·14
1841·64	124·0	6·60	−0·2	−0·04	1869·80	96·7	4·64	−1·0	+0·21
1842·57	123·8	6·57	−0·9	+0·06	1870·51	94·2	4·52	+0 3	+0·20
1842·60	123·5	6·79	−0·6	−0·18	1871·56	93·4	4·34	−0·6	+0·19
1843·55	122·1	6·57	+0·1	+0·10	1872·51	91·6	4·20	−0·7	+0·16
1844·44	121·3	6·66	+0·1	+0·02	1873·56	88·1	4·01	+0·7	+0·15
1845·48	120·9	6·64	−0·3	+0·07	1874·61	87·7	3·81	−1·4	+0·14
1846·46	119·3	6·76	+0·4	−0·01	1875·61	84·2	3·59	−0·5	+0·15
1847·47	119·1	6·85	−0·3	−0·11	1876·57	80·7	3·48	+0·3	+0·06
1848·38	118·4	6·81	−0·3	−0·06	1877·60	77·4	3·23	+0·4	+0·08
1849·39	118·1	6·64	−0·8	+0·10	1878·58	74·3	3·05	0·0	+0·05
1850·55	116·4	6·78	−0·1	−0·06	1879·57	69·5	2·95	+0·8	−0·05
1851·54	115·5	6·57	0·0	+0·11	1880·59	64·0	2·64	+1·4	+0·04
1852·69	114·9	6·56	−0·4	+0·09	1881·56	60 3	2·55	−0·3	−0·05
1853·57	114·9	6·42	−1·1	+0·19	1882·60	52·5	2·48	+0·9	−0·17
1854·48	113·2	6·37	−0·3	+0·20	1883·62	44·0	2·31	+2·0	−0·16
1855·52	113·3	6·45	−1·3	+0·06	1884·56	36·0	2·17	+2·3	−0·13
1856·43	111·7	6·34	−0·5	+0·10	1885·61	25·9	2·06	+2·6	−0·12
1857·52	111·0	6·31	−0·8	+0 07	1886·61	14·3	1·93	+4·1	−0·01

* *Mem. R.A.S.* liii.

Date.	Position Angle.	Distance.	C−O Angle.	C−O Distance.
	°	″	°	″
1887·68	3·8	1·91	+2·8	−0·01
1888·62	353·9	2·11	+2·5	−0·21
1889·53	345·9	2·08	+1·1	−0·10
1890·57	336·7	2·21	+0·2	−0·17
1891·59	327·4	2·23	+0·7	−0·11
1892·52	320·8	2·26	−0·2	−0·09
1893·62	312·9	2·25	−1·2	−0·05
1894·69	304·2	2·30	−0·7	−0·09
1895·32	298·6	2·22	−0·1	−0·05
1895·64	296·1	2·14	−0·1	+0·02
1896·61	289·0	2·31	−1·3	−0·26
1897·55	279·7	1·80	−1·0	+0·10
1898·55	270·7	1·91	−2·4	−0·07

The fact must be insisted on that no endeavour has been made to give a definitive orbit to 70 *Ophiuchi*, and nothing more has been attempted than to give a practical illustration of the working of the general method. Herein lies the justification for the merely rough adjustment of the elements T, P, and *a*. The other elements used are those given above, and as regards these an improved value might probably be assigned to the inclination. The value given rests on the measurement S N=6·15 mm., F N=11·5 mm. Greater relative accuracy can be attained in the measurement of longer lines, and it is therefore better to rely on the equivalent ratio $1n/1'n$ (fig. 2), for which, on reference to the original drawing, I find $1n$=31·3 mm., $1'n$=60·0 mm. These measurements give

$$i=58°33'.$$

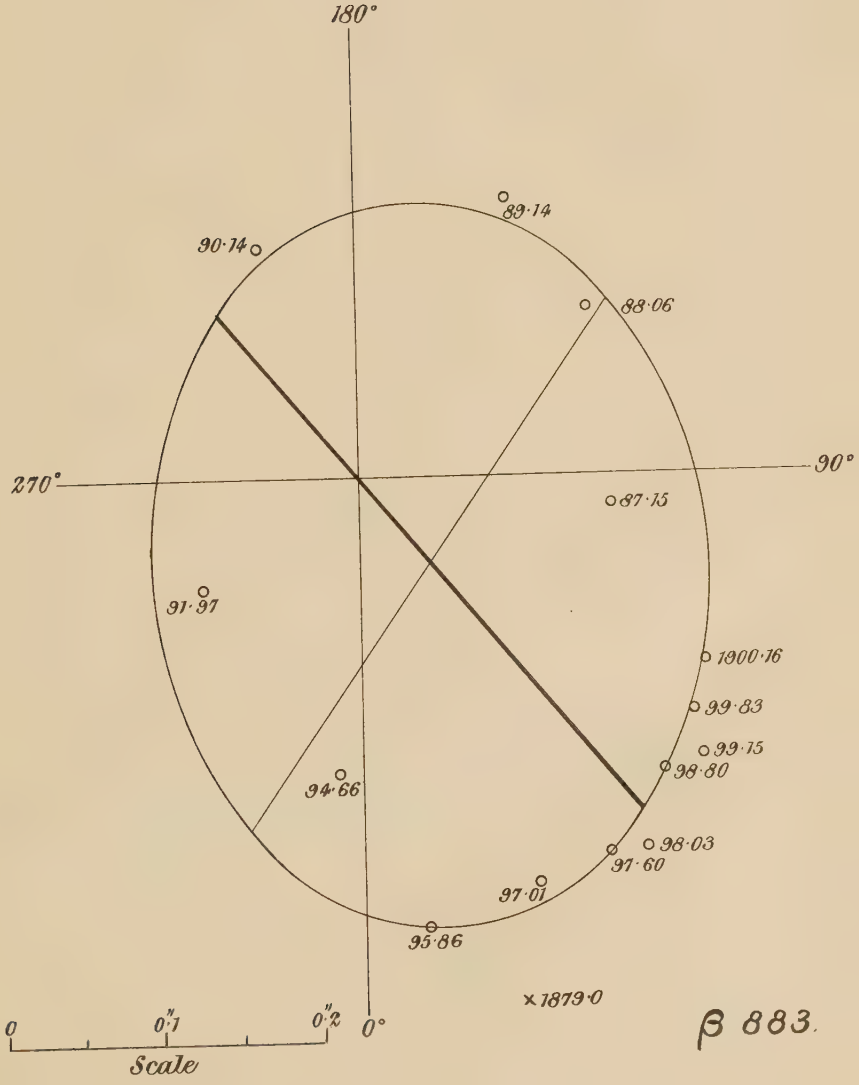
1900 *April* 10.

On the Orbit of β 883. By T. Lewis.

The uncertainty in the period of this double star arises in the first instance from the difficulty in fixing the proper quadrant owing to the components being of nearly equal magnitude; and secondly, by reason of their closeness, the distance between the two stars never exceeding 0″·3.

Dr. See has assigned a period of 5½ years, which makes *β* 883 the most rapid binary known. On the other hand, Professor Glasenapp's period of 16·8 years would merely rank it amongst the most rapid pairs.

Since 1896 this star has been under almost continuous observation, and hence the area swept out during these four years may be taken as a standard area affected with but small error. Working backwards with this argument, it became at once evident that Burnham's measure in 1891·97 really belonged to the third quadrant. Admitting this, we must place the observations of 1894 and 1895 in the opposite quadrants set down by the observer. These are all the changes requisite, and are shown in the following means by brackets :—


180°
89·14
90·14
88·06
270°
90°
87·15
91·97
1900·16
99·83
99·15
98·80
94·66
98·03
97·60
97·01
95·86
×1879·0
0
0″·1
0″·2
0°
Scale
β 883.

Date.	Angle.	Distance.	Observers.	Weight.
	°	"		
1879·00	17·5	0·35	Burnham	1
87·15	84·7	0·15	Schiaparelli	3
88·06	124·4	0·18	Schiaparelli	2
89·14	158·5	0·20	Schiaparelli	4
90·14	203·4	0·16	Schiaparelli	3
91·14	Single		Burnham	2
91·15	Single		Schiaparelli	7
91·97	[123·1]	0·12	Burnham	3
93·12	Single		Schiaparelli	2
94·66	[176·4]	0·19	Barnard	3
95·86	[188·4]	0·29	See, Schiaparelli	
97·01	24·9	0·28	Burnham, Bryant	
97·60	34·5	0·29	Barnard, Bowyer	
98·03	37·6	0·30	Brown, See	
98·80	46·9	0·28	Hussey, Dyson	
99·15	51·1	0·27	Schiaparelli	
1899·83	56·2	0·26	Cogshall, Lewis	
1900·16	62·3	0·25		

The numerals show the number of nights of observation which in the later groups range from 15 to 20.

The apparent orbit finally adopted is shown on Plate 16, with the above places plotted down. The dark line represents the projected major axis, and is so placed that the period and periastron may be easily checked.

The features of the adopted orbit are—

(1) The few changes of quadrant necessary.
(2) The inclusion of the negative results of 1891.
(3) The attempt to satisfy the original measure of 1879.

This observation is affected by an error of some kind, and would look better as $-17°{\cdot}5$. This is, however, of no great importance, the object being to decide between a $5\frac{1}{2}$-year period and one roughly three times this value.

The elements are :

T	1890·6	☊	177° 6′
P	15·8 years	λ	49° 4′
e	·359	γ	41° 18′
a	0″·24		

1900 *March* 20.

Results of Micrometer Measures of Double Stars made with the 28-inch Refractor at the Royal Observatory, Greenwich, in the year 1899.

(*Communicated by the Astronomer Royal.*)

The measures were made with a bifilar position-micrometer on the 28-inch refractor, aperture 28 inches, focal length 28 feet. The power generally used was 670, but when the definition permitted, a power of 1030 was used for observing very close pairs. A blue shade was used to diminish the light and irradiation when bright stars were observed. The observations were made in variously coloured fields, or in a dark field with illuminated wires.

Altogether 563 pairs have been measured, of which 130 are less than 0″·5 apart, 124 are between 0″·5 and 1″·0, 126 between 1″·0 and 2″·0, 80 between 2″·0 and 3″·0, and 103 over 3″·0. The majority of the last group are stars with very faint companions, such as *Aldebaran*, *β Cygni*, and *β Aquilæ*.

The initials in the last column are those of the observers, viz.—D., Mr. Dyson; C., Mr. Cowell; L., Mr. Lewis; B., Mr. Bryant; W. B., Mr. Bowyer; and P. M., Mr. Melotte.

Micrometric Observations of Double Stars.

Star's Name.	R.A. 1900.	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch 1899.	Obs.
	h m	° ′	°	″					
Krueger 1 ...	0 6	32 43	194·6	2·00	1	9·1	9·2	·011	B.
OΣ 2 ...	0 8	63 35	37·1	0·47	1	6·5	8·0	·852	W.B.
β 864 ...	0 8	55 12	149·4	2·02	1	8·6	11·9	·893	L.
β 1015 ...	0 14	78 16	122·5	0·45	1	8·2	8·3	·906	W.B.
β 1093 ...	0 15	73 36	62·6	0·42	1	7·3	8·2	·906	W.B.
OΣ 12 ...	0 26	36 8	149·7	0·36	1	5·0	6·0	·011	B.
β 865 ...	0 39	47 20	196·9	1·34	1	8·4	8·9	·011	B.
β 866 ...	0 40	47 20	74·8	1·44	1	9·1	9·1	·011	B.
β 495 ...	0 42	71 52	222·5	0·47	2	7·6	7·7	·868	W.B.
Σ 60 (η Cassiopeiæ)	0 42	32 44	219·9	5·21	1	4·0	7·6	·011	B.
OΣ 20 ...	0 49	71 22	321·8	0·43	1	5·9	7·0	·906	W.B.
Σ 73 (36 Andromedæ)	0 49	66 55	16·9	0·93	2	6·2	6·8	·868	W.B.
Σ 79 ...	0 54	45 44	191·7	7·88	1	6·0	7·0	·068	B.
β 303 ...	1 4	66 44	283·8	0·54	1	7·2	7·5	·906	W.B.
Σ 97 ...	1 6	48 59	101·8	4·51	1	8·5	8·7	·068	B.
Σ 122 ...	1 22	86 59	327·1	6·02	1	7·9	9·0	·063	W.B.
			329·7	6·04	1	...		·066	L.
			327·7	5·89	1	...		·068	B.

Star's Name.	R.A. 1900.	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch 1899.	Obs.
	h m	° ′	°	″				
β 1164 ...	1 22	84 10	174·0	0·31	1	6·7 7·0	·025	B.
Σ 135 ...	1 28	54 18	219·1	1·53	1	8·9 10·7	·011	B.
β 507 ...	1 30	63 44	157·0	2·21	1	8·0 11·0	·846	L.
Σ 138 ...	1 30	82 52	219·1	1·53	1	7·3 7·3	·011	B.
Σ 141 ...	1 35	51 32	299·7	1·50	1	8·0 8·5	·063	W.B.
			303·1	1·96	1	...	·068	B.
Σ 157 ...	1 41	51 34	193·9	1·02	1	8·5 8·7	·071	L.
A.C.	...	...	116·0	12·35	1	8·5 11·0	·071	L.
Σ 158 ...	1 41	57 20	262·6	1·86	1	8·3 8·8	·011	B.
			259·9	2·03	1	...	·140	W.B.
			259·3	1·86	1	...	·549	L
β 1016 ...	1 44	57 25	209·0	0·60	1	8·5 8·5	·068	B.
			210·6	0·64	1	...	·140	W.B.
			211·6	0·55	3	...	·460	L.
Hough. 311	1 45	65 50	178·3	0·43	1	7·5 7·7	·906	W.B.
Σ 183 A.B.	1 49	61 41	357·7	0·44	1	7·5 8·2	·011	B.
			358·9	0·52	5	...	·480	L.
			358·6	0·47	2	...	·523	W.B.
A.C.	...	...	162·2	5·12	1	7·5 8·9	·011	B.
			160·9	5·55	4	...	·480	L.
			161·2	5·32	2	...	·523	W.B.
Σ 189 ...	1 52	71 32	266·6	8·84	1	8·7 9·8	·063	W.B.
			269·0	9·00	1	...	·068	B.
OΣ 38 (γ Andromedæ)	1 58	48 10	116·3	0·31	4	5·0 6·2	·663	L.
Σ 208 ...	1 58	64 33	64·5	0·46	1	6·2 8·4	·011	B.
Hough. 497	2 6	53 7	66·3	0·51	1	8·2 9·0	·909	L.
Σ 228 ...	2 8	42 59	81·1	0·34	1	6·7 7·6	·068	B.
			80·0	0·43	1	...	·827	L.
Σ 258 ...	2 18	56 57	29·0	5·88	1	7·7 8·9	·071	L.
OΣ 44 ...	2 36	47 44	50·2	1·34	1	7·8 8·5	·011	B.
			55·7	1·29	1	...	·140	W.B.
β 262 ...	2 41	59 22	56·4	1·63	1	8·2 9·6	·071	L.
Σ 305 ...	2 42	71 2	314·8	2·85	2	7·3 8·2	·024	B.
β 524 ...	2 47	52 5	29·5	elong.	1	5·5 6·5	·071	L.
			19·7	0·16	1	...	·909	L.
β 525 ...	2 53	52 31	131·3	0·33	1	7·5 7·5	·036	B.
			132·6	0·16	2	...	·152	L.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 333 (ε Arietis)	2 53	69 4	198·8	1·44	2	5·7 6·0	·025	B.
			202·5	1·18	2	...	·533	L.
Σ 346 A.B.	2 59	65 8	91 5	0·42	1	6·0 6·0	·909	L.
A.C.	...	...	359·7	5 23	1	...	·909	L.
β 1030 ...	3 4	68 39	168·2	0·39	1	8·4 8 4	·090	B.
			157·1	0·46	3	...	·405	L.
β 530 ...	3 8	67 25	194·2	1 99	2	9·7 10·1	·153	L.
β 878 ...	3 22	67 32	83·7	0·37	1	5·8 13 0	·156	L.
Σ 412 (7 Tauri)	3 28	65 52	5 0	0·22	2	6 6 6·7	·529	L.
Σ 410 ...	3 29	58 19	205 7	11·64	1	7·8 11·8	·909	L.
β 533 ...	3 29	58 39	50·5	0·64	...	7·0 7·0	·269	L.
β 535 ...	3 38	58 2	50·8	1 00	1	3·8 8·5	·171	L.
Σ 439 A.C.	3 38	58 9	39·6	24·00	1	8·7 9·1	·102	L.
β 880 A.B.	...	...	353·2	0·49	4	8·7 8·9	·085	L.
			360·2	0·39	2	...	·123	B.
β 1184 ...	3 42	67 56	263 3	0·48	1	8·1 8·3	·011	B.
			276·3	0 65	1	...	·148	L.
β 536 A.B.	3 40	66 6	298 5	elong.	1	8·3 8·9	·149	L.
C.D.	...	...	10·1	18·71	1	8 0 12·0	·149	L.
Σ 471 (ε Persei)	3 51	50 17	7·8	8·81	1	3·1 8·3	·200	L.
OΣ 531 ...	4 0	52 12	129·2	1·82	1	8·5 10·2	·113	W.B.
			129·1	1·71	1	...	·129	L.
β 1232 ...	4 2	61 6	352·8	0·39	1	8·5 9·5	·150	L.
Hough. 326	4 2	61 40	172·4	0·36	2	8·5 8·5	·150	L.
			175·1	0·19	1	...	·197	B.
OΣ 77 ...	4 9	58 34	166 1	0·24	3	7·0 7·5	·096	L.
			143·0	0·15	1	...	·197	B.
OΣ 79 ...	4 14	73 45	61·5	0·39	1	6·4 7·6	·068	B.
OΣ 80 ...	4 17	47 46	184·8	0 63	1	6·5 7·0	·068	B.
			181·2	0 56	2	...	·182	L.
Σ 535 ...	4 17	78 53	327·3	1·51	2	6·7 8·2	·030	B.
			323 7	1·70	2	...	·510	W.B.
OΣ 82 ...	4 18	75 12	129·3	0·59	1	8·0 8·7	·040	B.
			128·3	0·36	1	...	·063	W.B.
			123·8	0·51	1	...	·947	L.
β 1235 ...	4 18	67 29	60·6	0·31	2	8·4 8·5	·556	L.
β 745 ...	4 19	36 7	136·0	0 70	1	8·3 8·3	·203	L.

Star's Name.	R.A. 1900.	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch 1899.	Obs.
	h m	° ′	°	″				
Hastings ...	4 30	70 29	54·8	0·36	1	8·0 9·0	·071	L.
			53·5	0·48	1	...	·142	W.B.
β 550 (Aldebaran) A.B.	4 30	73 42	110·8	31·08	3	1 14	·144	L.
β 1031 (Aldebaran) C.D.	...	...	277·2	2·01	2	10½ 13½	·103	L.
OΣ 86 ...	4 31	70 27	58·7	0·46	1	7·5 7·5	·011	L.
			58·8	0·49	1	...	·068	B.
Σ 567 ...	4 31	70 44	323·5	1·98	1	8·5 9·0	·025	B.
			320·4	1·89	1	...	·063	W.B.
			322·7	2·17	1	...	·071	L.
Σ 572 ...	4 32	63 16	203·0	3·61	1	6·5 6·5	·036	B.
			202·1	3·08	1	...	·036	C.
			199·7	3·65	1	...	·142	W.B.
* ...	4 34	63 16	213·4	0·82	1	8·0 9·0	·151	L.*
β 883 ...	4 45	79 6	49·8	0·36	5	7·5 13·0	·097	L.
			48·8	0·40	1	...	·142	W.B.
			56·6	0·28	1	...	·947	L.
			58·3	0·29	1	...	·956	W.B.
β 552 ...	4 46	76 31	206·1	0·37	1	6·9 10·2	·156	L.
OΣ 98 ...	5 2	81 39	181·5	0·98	1	5·5 7·0	·025	B.
			175·1	0·66	1	...	·063	W.B.
			180·9	0·77	1	...	·947	L.
Σ 645 A.C.	5 3	62 5	25·6	12·05	1	6·0 8·5	·151	L.
β 1047 B.C.	...	...	61·3	0·46	1	8·5 8·8	·151	L.
Σ 687 A.B.	5 16	56 18	70·3	17·35	2	8·2 8·8	·176	L.
A.C.	...	...	153·5	48·78	2	8·2 8·8	·176	L.
β 886 C.D.	...	...	258·0	0·82	2	8·8 9·8	·176	L.
OΣ 105 ...	5 16	77 26	113·6	0·52	1	7·8 7·8	·151	L.
			109·5	0·47	1	...	·186	W.B.
β 887 A.B.	5 16	56 41	191·4	0·98	2	8·9 9·7	·176	L.
A.C.	...	...	113·9	9·87	2	8·9 13·0	·176	L.
A.D.	...	...	332·3	10·82	1	8·9 11·8	·176	L.
Dawes 5 (η Orionis)	5 19	92 29	78·1	1·33	1	3·5 5·5	·025	B.
β 889 A.B.	5 20	55 40	225·6	0·87	4	8·4 9·3	·130	L.
A.C.	...	...	104·1	3·97	1	... 14·1	·160	L.
A.D.	...	...	109·2	11·42	2	... 13·6	·160	L.

* Probably β 1044.

Star's Name.		R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 707	A.E.	...	...	132·8	18·24	3	... 10·0	·122	L.
*	...	5 21	55 20	302·5	2·30	1	8 11	·047	L.
Σ 719	A.B.	5 24	60 32	328·1	0·98	2	7·0 9·5	·176	L.
				328·4	1·04	1	...	·183	W.B.
	A.C.	...	...	350·9	15·01	3	7·0 8·9	·166	L.
Σ 749	...	5 31	63 8	173·7	0·85	1	7·1 7·2	·031	B.
				170·7	0·77	1	...	·063	W.B.
				173·8	0·82	1	...	·175	L.
β 1240	A.B.	5 32	59 34	351·0	0·20	3	5·6 6·0	·136	L.
Σ 753	A.C.	...	...	268·8	12·60	3	... 8·7	·136	L.
OΣ 112	...	5 33	52 6	73·8	0·62	2	7·5 7·5	·162	L.
				71·2	0·34	1	...	·189	W.B.
				73·3	0·63	1	...	·197	B.
β 91	...	5 41	69 6	90·6	1·43	1	8·1 10·0	·947	L.
OΣ 118	...	5 42	69 10	320·5	0·61	1	8·0 8·8	·036	B.
				312·8	0·58	2	...	·096	W.B.
				307·3	0·45	1	...	·947	L.
β 560	...	5 43	60 18	161·5	0·83	1	8·0 8·5	·036	C.
Σ 799	...	5 45	51 31	181·6	0·74	1	7·0 8·0	·085	W.B.
				179·2	0·85	1	...	·222	B.
				183·3	0·93	1	...	·233	L.
Σ 826	...	5 53	91 18	123·2	2·05	2	8·2 9·2	·110	L.
				159·8	0·45	1	...	·036	B.
β 1058 (4 Geminorum)		6 4	67 0	282·1	0·32	2	6·5 6·6	·192	W.B.
Σ 888	...	6 14	61 31	252·5	2·94	3	7·5 9·2	·088	L.
Σ 888	A.C.	6 14	61 31	252·5	2·94	3	7·5 9·2	·088	L.
β 895	A.B.	...	...	167·9	0·28	2	8·2 8·4	·155	L.
Σ 899	...	6 17	72 22	20·4	2·39	2	7·0 9·0	·123	B.
β 1020	...	6 17	61 11	157·8	1·01	3	8·2 10·0	·088	L.
Σ 919	A.B.	6 24	96 57	132·4	7·29	1	5·0 5·5	·953	B.
	B.C.	...	...	102·8	2·93	1	5·5 6·0	·953	B.
β 1021	...	6 25	61 33	86·9	0·68	2	8·1 9·4	·109	L.
Σ 932	...	6 28	75 10	322·9	2·18	2	8·2 8·3	·123	B.
Σ 936	...	6 30	31 48	266·4	1·52	2	7·0 8·7	·042	L.
OΣ 149	...	6 30	62 38	277·8	0·68	2	6·5 9·0	·107	W.B.
				278·7	0·68	2	...	·111	L.
Σ 945	...	6 33	48 56	267·0	0·75	1	7·1 8·0	·066	L.
				268·4	0·83	1	...	·090	B.

Star's Name.	R.A. 1900. h m	N.P.D 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights	Mags.	Epoch 1899.	Obs.
Σ 946 ...	6 36	30 24	129·8	4·06	1	7·2 9·0	·036	B.
Σ 948 ...	6 37	30 27	120·3	1·57	1	5·2 6·1	·036	B.
OΣ 156 ...	6 41	71 41	306·5	0·75	1	7·0 7·0	·066	L.
			297·1	0·59	3	...	·136	W.B.
OΣ 160 ...	6 48	68 42	172·1	1·18	3	7·0 10·0	·167	W.B.
β 899 A.B.	6 53	71 8	268·3	0·56	2	8·7 9·3	·185	L.
A.C.	...	...	175·3	24·66	1	8·7 10·0	·066	L.
A.D.	...	...	48·0	41·12	1	8·7 9·0	·066	L.
β 900 ...	7 0	68 49	275·6	1·50	3	8·0 11·5	·198	L.
OΣ 165 ...	7 2	73 54	40·4	3·71	2	5 11	·108	L.
β 1009 ...	7 5	59 36	183·6	2·10	1	4·5 13·2	·219	L.
Σ 1037 A.B.	7 6	62 35	305·0	0·92	1	7·0 7·1	·066	L.
			304·2	0·86	1	...	·090	B.
			299·0	0·84	3	...	·118	W.B.
β 1023 ...	7 9	63 56	301·5	0·21	2	8·4 8·5	·222	L.
OΣ 170 ...	7 11	80 31	111·3	1·54	1	7·0 7·5	·145	B.
			109·8	1·38	1	...	·162	W.B.
Σ 1074 ...	7 15	89 24	140·9	0·36	1	7·5 8·5	·060	B.
			138·1	0·55	1	...	·085	W.B.
β 1024 ...	7 17	60 30	164·5	2·38	1	9·0 11·3	·225	L.
OΣ 175 ...	7 28	58 50	333·4	0·73	2	6·0 6·6	·058	B.
			333·0	0·45	1	...	·084	W.B.
			334·5	0·61	3	...	·153	L.
Σ 1110 (Castor)	7 28	57 53	225·6	5·50	1	2·7 3·7	·025	B.
			224·3	5·64	2	...	·111	L.
β 579 ...	7 28	56 38	218·2	0·86	1	7·9 10·0	·219	L.
OΣ 176 ...	7 33	89 14	211·1	1·56	2	7·3 7·3	·162	B.
Σ 1126 ...	7 34	84 28	144·8	1·15	2	7·0 7·0	·171	B.
			142·3	1·29	1	...	·194	W.B.
OΣ 177 ...	7 35	52 19	121·7	0·81	1	7·5 8·5	·041	M.
			120·2	0·68	1	...	·101	B.
			124·2	0·61	2	...	·118	W.B.
OΣ 182 ...	7 47	86 20	216·1	1·13	2	7·0 7·5	·162	B.
β 101 (9 Argus)	7 47	103 38	295·9	0·32	1	5·2 6·5	·036	B.
Σ 1157 ...	7 49	92 30	244·3	1·21	2	8·0 8·0	·162	B.
Σ 1175 ...	7 57	85 32	223·5	1·75	1	8 9	·060	B.
			223·4	1·70	1	...	·194	W.B.

Star's Name.	R.A. 1900.	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch 1899.	Obs.
	h m	° ′	°	″				
β 581 ...	7 59	77 26	272·9	0·37	1	8·5 8·6	·161	W.B.
OΣ 185 ...	7 52	88 35	195·1	0·37	1	6·8 7·1	·162	W.B.
			202·7	0·25	1	...	·192	B.
Σ 1187 ...	8 3	57 28	223·2	2·04	1	7·1 8·0	·041	W.B.
			224·9	2·17	1	...	·066	L.
			221·4	2·04	1	...	·090	B.
Σ 1196 A.B. (ζ Cancri)	8 6	72 3	8·2	1·09	3	5·0 5·7	·119	L.
			7·3	1·14	2	...	·147	W.B.
A.C.	...	...	114·0	5·68	3	5·0 5·5	·119	L.
			113·7	5·23	2	...	·147	W.B.
B.C.	...	...	127·2	5·78	3	5·7 5·5	·119	L.
			128·5	5·86	2	...	·147	W.B.
Σ 1202 ...	8 8	78 50	318·4	2·38	1	7·3 9·5	·129	W.B.
			320·0	2·51	1	...	·178	B.
β 1243 ...	8 8	72 1	301·7	0·92	1	7·2 12·2	·126	L.
β 1244 ...	8 8	87 41	40·7	0·63	1	7·9 8·1	·036	B.
Σ 1205 ...	8 11	33 14	175·9	0·98	1	8·8 9·3	·277	B.
Σ 1216 ...	8 16	91 14	193·9	0·47	2	7·5 8·2	·157	B.
Σ 1273 A.B. (ε Hydræ)	8 41	83 12	263·5	0·21	4	3·5 6·0	·230	L.
A.C.	...	...	233·1	3·81	1	3·5 7·4	·197	B.
			231·5	3·43	2	...	·210	L.
			235·7	3·38	1	...	·233	P.M.
A.D.	...	...	195·2	20·25	1	3·5 13·0	·233	L.
β 1068 ...	8 44	80 43	191·6	0·31	2	7·7 7·8	·178	W.B.
Perrotin ...	8 46	81 18	353·4	0·86	2	7·9 8·6	·135	W.B.
Σ 1316 A.B.	9 3	96 43	136·1	7·30	1	8·4 10·2	·277	B.
A.C.	...	...	170·7	7·32	1	8·4 10·0	·277	B.
B.C.	...	...	242·7	3·64	1	10·2 10·0	·277	B.
Σ 1321 ...	9 7	36 50	64·5	19·30	1	7·1 7·2	·277	B.
Σ 3121 ...	9 12	60 56	195·0	0·72	1	7·5 7·8	·126	L.
			194·9	0·60	1	...	·129	W.B.
			198·6	0·62	1	...	·197	B.
OΣ 201 ...	9 18	61 39	224·3	1·28	1	7·5 8·9	·126	L.
			219·5	1·25	1	...	·129	W.B.
			225·7	1·45	1	...	·197	B.
β 1070 ...	9 18	63 19	82·3	0·45	1	9·1 10·2	·126	L.
κ Leon's ...	9 19	63 2	202·7	2·83	1	...	·217	L.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 1348 ...	9 19	83 14	320·0	1·45	2	7·5 7·6	·169	W.B.
			323·4	1·86	1	...	·197	B.
Σ 1356 ...	9 23	80 27	111·6	0·64	4	6·2 7·0	·171	W.B.
β 1071 ...	9 27	37 54	87·1	5·00	1	3 14	·342	L.
Σ 1385 ...	9 44	72 55	352·5	0·78	1	8·4 11·1	·233	L.
OΣ 208 ...	9 45	35 28	283·3	0·23	3	5·0 5·6	·298	B.
			284·9	0·27	1	...	·405	L.
Σ 1389 ...	9 46	62 33	308·4	2·11	1	8·0 9·0	·183	W.B.
			313·4	2·08	1	...	·222	B.
			309·8	2·20	1	...	·290	L.
A.C. 5 ...	9 48	97 36	83·1	0·30	2	6 7	·279	B.
OΣ 215 ...	10 10	71 45	209·2	0·68	3	6·7 7·0	·171	W.B.
Σ 1424 ... (γ Leonis)	10 14	69 38	114·4	3·72	2	2·0 3·5	·192	W.B.
			113·7	3·68	2	...	·386	B.
Σ 1426 A.B.	10 15	83 2	280·8	0·69	2	7·8 8·3	·175	W.B.
A.C.	...	...	7·5	7·84	1	7·8 9·3	·189	W.B.
OΣ 216 ...	10 17	74 8	120·0	1·25	2	7 11	·259	B.
			123·6	1·27	1	...	·372	L.
Σ 1429 ...	10 19	64 50	250·1	0·95	3	8·1 8·5	·162	W.B.
			256·0	0·77	1	...	·290	L.
OΣ 217 ...	10 21	72 15	330·7	0·69	2	7·3 7·8	·152	W.B.
OΣ 218 ...	10 22	85 56	76·6	0·95	1	7 9	·142	W.B.
			77·2	0·94	2	...	·279	B.
OΣ 222 ...	10 32	29 17	344·8	4·24	1	6·7 10	·405	L.
Σ 1457 ...	10 33	83 44	314·6	0·94	1	7·4 8·2	·142	W.B.
			315·6	1·35	1	...	·197	B.
OΣ 224 ...	10 34	80 38	309·6	0·40	4	7·4 8·5	·341	B.
OΣ 225 A.B.	10 35	70 15	248·0	0·83	1	8·2 11·2	·189	W.B.
			250·3	0·65	4	...	·270	L.
A.C.	...	...	351·7	6·13	1	8·2 10·0	·189	W.B.
			352·1	6·44	3	...	·249	L.
OΣ 227 ...	10 37	78 44	346·1	0·40	1	8 9	·162	W.B.
			346·5	0·58	1	...	·222	B.
			341·6	0·48	1	...	·224	L.
Σ 1465 ...	10 37	44 50	8·6	1·88	1	8·7 9·2	·405	L.
			6·9	2·00	1	...	·413	W.B.
OΣ 228 ...	10 42	66 47	185·7	0·36	4	7 8	·164	W.B.
			189·2	0·48	1	...	·290	L.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
OΣ 229 ...	10 44	48 21	320·1	0·82	2	6 7	·156	B.
			321·1	0·76	1	...	·389	L.
β 915 ...	10 44	65 11	227·8	0·95	1	9 9	·322	L.
			233·5	0·73	1	...	·375	B.
Σ 1476 ...	10 44	93 27	2·5	2·33	1	6·8 7·8	·277	B.
Σ 1487 ...	10 50	64 40	105·4	6·38	2	4·5 6·7	·250	B.
Σ 1500 ...	10 55	92 52	310·3	1·52	1	7·8 8·2	·277	B.
Σ 1501 ...	10 56	58 38	184·2	1·86	1	7·5 8·0	·222	B.
Σ 1504 ...	10 59	85 47	286·1	1·10	2	7·4 7·5	·241	W.B.
			287·4	1·13	1	...	·342	L.
β 599 ...	11 2	87 30	91·4	1·22	1	5·6 10·5	·342	L.
Σ 1510 ...	11 2	36 38	334·4	4·46	1	7·2 8·4	·222	B.
Σ 1517 ...	11 9	69 :8	98·2	0·29	2	7·0 7·5	·348	L.
Σ 1519 ...	11 10	29 40	290·6	1·26	1	8·2 9·2	·222	B.
Σ 1522 ...	11 11	87 52	180·1	2·61	1	8·9 11·1	·277	B.
			184·2	3·05	1	...	·342	L.
Σ 1523 (ξ Urs. Maj.)	11 13	57 53	155·7	2·15	2	4·0 4·9	·239	B.
			154·5	2·04	1	...	·353	L.
Σ 1534 ...	11 16	71 14	328·6	5·45	1	8·0 11·0	·474	B.
Σ 1536 ...	11 18	78 54	55·9	2·20	1	3·9 7·1	·255	B.
Σ 1527 ...	11 14	75 9	18·1	3·39	1	7·1 8·0	·222	B.
			19·7	3·60	1	...	·329	L.
Σ 1542 ...	11 23	44 54	259·4	3·21	1	7·0 10·2	·405	L.
			264·3	3·18	1	...	·435	W.B.
Lal. 21846...	11 24	58 59	4·7	0·82	2	7 11	·400	L.
OΣ 234 ...	11 26	48 11	134·2	0·34	3	7·0 7·4	·392	L.
OΣ 235 ...	11 26	28 20	112·4	0·59	2	6 7	·156	B.
Σ 1554 ...	11 31	76 36	251·5	0·69	...	8 9 9·1	·222	...
			258·6	0·72	...	...	·290	...
Σ 1555 A.B.	11 31	61 38	353·1	0·38	3	6·4 6·8	·286	L.
			351·4	0·48	1	...	·304	W.B.
A.C.	...	...	146·5	20·76	1	6·4 10·3	·290	L.
			144·7	21·02	1	...	·304	W.B.
Σ 1558 ...	11 33	67 56	152·5	1·39	1	8·7 9·2	·183	W.B.
			158·3	1·32	1	...	·222	B.
OΣ 237 ...	11 33	48 16	272·2	1·10	1	8 9	·381	L.
Σ 1566 ...	11 34	68 25	350·5	2·74	1	8·1 10·3	·222	B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
β 603 ...	11 45	75 9	318·9	0·75	1	6·4 10·3	·222	B.
			322·2	0·78	2	...	·316	L.
Σ 1586 ...	11 52	49 6	251·7	1·64	2	8·2 10·2	·430	L.
			252·6	1·53	1	...	·435	W.B.
Σ 1601 ...	12 1	50 35	311·6	2·55	1	8·5 9·7	·183	W.B.
			305·8	2·32	1	...	·268	L.
			307·8	2·00	1	...	·408	B.
Σ 1606 ...	12 5	49 31	331·1	0·97	1	6·2 7·0	·405	L.
			329·2	1·00	1	...	·408	B.
Ho. 52 ... (11 Comæ)	12 15	71 39	44·1	8·80	2	5 13	·356	L.
Σ 1613 ...	12 18	53 40	14·5	1·00	1	8·2 8·4	·183	W.B.
			12·3	1·40	2	...	·362	L.
Σ 1639 ...	12 19	63 52	182·6	0·23	3	6·5 8·0	·328	L.
Σ 1643 ...	12 22	62 23	38·5	1·89	1	8·3 8·6	·238	W.B.
			39·6	2·03	2	...	·316	L.
Σ 1647 ...	12 25	79 44	218·6	1·34	1	7·5 8·0	·222	B.
			219·8	1·38	1	...	·290	L.
			223·0	1·22	1	...	·293	W.B.
Σ 1658 ...	12 30	81 58	358·1	2·24	1	8·0 9·8	·222	B.
			358·1	2·32	1	...	·290	L.
Σ 1663 ...	12 32	68 13	104·5	0·55	3	7·8 8·7	·293	W.B.
			102·3	0·59	2	...	·344	L.
Σ 1670 ... (γ Virginis)	12 36	90 52	147·7	5·58	1	3·0 3·0	·359	W.B.
			151·7	5·98	2	...	·386	B.
Σ 1687 A.B.	12 48	68 11	79·3	1·00	1	5·1 7·8	·293	W.B.
			80·2	1·09	3	...	·343	L.
			77·3	1·13	1	...	·397	B.
β 112 ...	12 55	71 4	294·6	2·12	1	9·1 9·8	·372	L.
			291·9	2·00	1	...	·397	B.
β 1082 ...	12 57	33 5	88·6	1·29	1	6·0 9·6	·038	B.
Σ 1711 ...	12 57	75 59	348·3	0·77	2	8·5 9·0	·332	W.B.
			351·8	1·03	1	...	·397	B.
β 929 ...	12 58	93 10	218·8	0·49	1	6·0 6·3	·397	B.
β 1083 A.B.	13 2	60 25	225·0	6·63	2	6·5 11·5	·325	L.
B.C.	...	...	225·0	0·58	1	11·5 11·7	·385	L.
* ...	13 2	62 31	192·3	0·43	1	9·0 9·5	·296	L.

Star's Name.	R.A. 1900.	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch 1899.	Obs.
	h m	° ′	°	″				
OΣ 260 ...	13 3	62 31	119·9	0·65	1	8 8	·293	W.B.
			125·6	0·64	4	...	·328	L.
Σ 1728 ...	13 5	71 54	183·5	0·17	1	5·5 5·9	·293	W.B.
			187·0	0·25	4	...	·315	L.
OΣ 261 ...	13 7	57 22	346·9	1·38	3	7·0 7·5	·394	L.
			346·4	1·37	1	...	·490	B.
β 800 ...	13 12	72 26	117·6	2·56	3	7·5 10·2	·303	L.
			112 4	2·41	1	...	·490	B.
Σ 1734 ...	13 15	86 30	189·8	0·98	2	7 8	·386	B.
Σ 1742 ...	13 19	88 4	351·6	1·21	1	7·4 7·9	·375	B.
Ho. 260 ...	13 19	60 15	318·4	0·74	2	8·1 8·2	·374	L.
OΣ 266 ...	13 23	73 41	333·0	1·78	1	7·3 7 8	·274	L.
			340·4	1·57	1	...	·408	B.
Σ 1752 ...	13 26	29 30	141·4	1·33	1	7·8 9·8	·451	B.
Σ 1755 ...	13 28	52 40	131·3	4·31	1	6·8 7·9	·408	B.
OΣ 269 ...	13 28	54 34	217·8	0·36	1	6·5 7·0	·359	W.B.
			221·2	0·36	2	...	·375	L.
			210·3	0·40	1	...	·408	B.
Σ 1757 ...	13 29	89 45	78·5	2·24	1	8 9	·408	B.
Σ 1758 ...	13 29	40 25	302·9	3·71	1	8·0 8·5	·408	B.
Σ 1768 ...	13 33	53 10	127·8	1·19	1	5·0 7·6	·297	B.
			130·7	0·89	3	...	·402	L.
β 612 ...	13 34	78 45	228·5	0·30	1	6·0 6·5	·394	L.
			215·1	0·41	1	...	·397	B.
Σ 1772 ...	13 36	69 30	140·9	4·68	1	6·2 9·3	·408	B.
Σ 1777 ...	13 38	85 55	231·2	3·09	1	5·8 8·2	·408	B.
Σ 1781 ...	13 41	84 23	270·3	1·12	1	7·5 8·0	·408	B.
Σ 1785 ...	13 45	62 30	271·3	1·34	1	7·2 7·5	·296	L.
			274·2	1·28	2	...	·364	W.B.
			274·5	1·17	1	...	·408	B.
β 613 ...	13 47	54 50	144·0	0·71	1	9·1 9·1	·394	L.
			142·4	0·83	1	...	·397	B.
Σ 1788 ...	13 49	97 33	79·6	2·75	1	7 8	·297	B.
β 30 ...	13 53	70 2	199·9	8·37	1	8·0 11·0	·452	B.
β 1270 ...	13 59	81 2	334·3	...	1	8·2 8·3	·427	L.
Σ 1802 ...	14 2	102 22	280·3	4·98	1	7·7 8·7	·397	B.
Σ 1808 ...	14 5	62 54	75·3	2·76	1	8·0 9·0	·296	L.
			73·2	2·74	2		·392	W.B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 1810 ...	14 7	61 29	175·4	2·05	1	8·2 9·0	·293	W.B.
			176·7	1·93	2		·362	L.
OΣ 278 ...	14 8	45 21	95·4	0·27	3	7·5 7·5	·430	B.
Σ 1816 ...	14 9	60 26	84·6	1·25	1	7 7·1	·413	W.B.
			83·6	1·40	1		·427	L.
Σ 1817 ...	14 10	62 50	0·6	1·33	1	8·0 8·5	·293	W.B.
			3·4	1·12	2	...	·362	L.
Σ 1819 ...	14 10	86 22	2·5	1·21	1	7·9 8·0	·296	L.
			0·4	1·40	1	...	·452	B.
Σ 1832 ...	14 13	85 37	132·8	0·60	1	9 9	·296	L.
			132·5	0·40	1	...	·452	B.
β 1272 ...	14 14	40 47	131·2	1·24	2	8·4 9·5	·551	B.
β 1273 ...	14 15	41 35	192·8	1·02	2	8·6 9·8	·551	B.
Σ 1834 ...	14 17	22 58	200	elong.	1	7·5 7·5	·452	B.
Σ 1835 A.B.	14 18	81 16	190·3	6·44	1	5·0 8·2	·296	L.
β 1111 B.C.	...	...	28·8	0·25	1	8·2 8·2	·296	L.
Σ 1837 ...	14 19	101 12	301·8	1·23	2	7·0 8·0	·425	B.
Σ 1820 ...	14 20	34 11	75·2	2·10	1	7·8 8·0	·452	B.
Σ 1846 ...	14 23	91 44	110·3	4·29	1	5·2 9·4	·375	B.
Σ 1863 ...	14 34	37 55	90·2	0·72	1	7 7½	·452	B.
Σ 1865 (ζ Boötis)	14 36	75 49	62·4	...	2	3·5 3·9	·414	B.
Σ 1867 ...	14 36	58 15	11·3	1·03	1	7·7 8·2	·342	L.
			14·9	1·28	1	...	·649	B.
Σ 1877 (ε Boötis)	14 38	62 29	332·6	2·73	2	3·0 6·3	·362	L.
			326·3	2·86	1	...	·452	B.
Σ 1871 ...	14 38	38 6	291·4	1·88	2	7 7	·636	B.
Σ 1876 ...	14 41	90 46	79·7	1·27	1	8·0 8·4	·452	B.
Σ 1879 ...	14 41	79 55	130·7	0 45	1	8·0 8·5	·293	W.B.
			142·7	0·48	2	...	·373	L.
OΣ 285 ...	14 42	47 11	135·2	0·34	3	7·1 7·6	327	L.
Σ 1883 ...	14 44	83 38	242·3	0·44	2	7·0 7·0	·425	B.
Σ 1884 ...	14 44	65 12	54·3	1·48	1	6·3 7·4	·375	B.
			54·2	1·53	1	...	·427	L.
Σ 1885 ...	14 46	89 34	144·1	3·73	1	8·4 8·9	·397	B.
Σ 1888 ...	14 47	70 27	209·5	2·52	1	5·1 7·4	·375	B.
			207·3	2·89	1	...	·427	L.
OΣ 287 ...	14 57	44 38	319·9	0·73	2	8 9	·345	L.
			324·9	0·77	1	...	·452	B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
β 31 A.B.	14 48	70 50	196·2	1·39	2	8·4 9·7	·436	L.
			201·8	1·10	1	...	·452	B.
A.C.	...	...	...	...	...	8·4 12·2	...	...
Σ 1891 ...	14 51	55 28	239·2	3·74	1	8·4 10·0	·397	B.
Σ 1908 ...	15 1	55 7	142·3	1·41	1	8 9	·356	L.
			138·9	1·19	1	...	·375	B.
Hough 60 ...	15 10	54 44	41·7	0·28	1	8 8	·334	L.
			31·7	0·19	1	...	·375	B.
Σ 1926 ...	15 12	51 20	252·0	0·84	1	7·7 9·2	·353	L.
Σ 1932 ...	15 14	62 45	149·1	0·62	1	5·5 6	·375	B.
			148·6	0·71	4	...	·418	L.
			145·6	1·05	2	...	·424	W.B.
Hough 62 ...	15 17	54 40	283·9	1·18	2	8·2 8·3	·512	B.
Σ 1937 ...	15 19	59 19	172·0	0·57	2	5 5·5	·345	L.
			171·4	0·66	1	...	·356	D.
			175·6	0·31	1	...	·375	B.
Σ 1938 ...	15 20	52 16	75·7	0·83	2	4 6	·345	L.
			74·0	1·17	1	...	·356	D.
			78·4	1·10	1	...	·375	B.
Σ 1954 ...	15 30	29 7	187·8	3·72	1	3·9 5·5	·375	B.
			187·0	3·53	1	...	·444	L.
Σ 1957 ...	15 31	76 44	156·0	0·97	1	8·0 9·5	·449	L.
			152·8	0·99	2	...	·463	W.B.
OΣ 298 ...	15 32	49 50	176·2	1·16	1	7 8	·334	L.
			183·1	0·85	1	...	·649	B.
Σ 1967 ... (γ Cor.Bor.)	15 38	63 18	118·2	0·34	2	4·0 7·0	·414	B.
			117·0	0·43	3	...	·416	L.
Σ 1974 ...	15 44	92 51	104·1	2·34	1	8·5 8·7	·452	B.
OΣ 303 ...	15 56	76 28	145·8	0·68	1	7·0 8·0	·375	B.
			144·9	0·71	1	...	·449	L.
			139·6	0·77	3	...	·453	W.B.
Σ 2004 ...	16 0	60 52	282·4	1·74	1	8·7 9·7	·375	B.
			277·6	1·58	2	...	·392	L.
Σ 2011 ...	16 4	60 44	67·8	2·44	1	7·2 9·8	·375	B.
			66·8	2·14	2	...	·392	L.
Σ 2015 A.C.	16 5	44 21	157·7	2·81	1	7·8 8·8	·616	B.
			158·6	2·83	1	...	·695	W.B.
β 355 A.B.	16 5	44 21	277·7	0·28	1	7·8 8·9	·695	W.B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 2022 A.D.	16 9	63 4	136·6	2·55	1	6·2 9·8	·427	L.
			131·1	2·12	1	...	·446	W.B.
Σ 2032 ...	16 11	55 53	212·6	4·34	3	5·0 6·1	·532	B.
Σ 2026 ...	16 12	82 21	269·3	0·69	1	8·5 9·5	·542	L.
Σ 2037 ...	16 15	37 14	236·6	1·35	1	9 9	·446	W.B.
β 951 ...	16 20	56 26	51·7	0·87	3	8·1 9·0	·409	L.
Σ 2052 ...	16 24	71 21	92·0	1·80	1	7·5 7·5	·542	L.
			93·6	1·81	1	...	·605	B.
β 814 ...	16 24	49 53	323·1	0·33	1	8·4 8·4	·411	L.
Σ 2054 ...	16 24	28 4	1·0	0·95	1	5·7 6·9	·512	W.B.
			357·5	1·22	1	...	·530	B.
OΣ 312 ...	16 24	28 16	141·4	4·95	1	2·1 8·1	·512	W.B.
			139·7	5·16	1	...	·536	B.
Σ 2055 (λ Ophiuchi)	16 25	87 47	54·8	1·07	1	4·0 6·1	·444	L.
			54·4	1·24	1	...	·682	B.
Σ 3105 ...	16 26	96 48	28·3	0·45	1	7·5 7·5	·444	L.
			266·3	0·57	3	...	·328	L.
Σ 2084 (ζ Herculis)	16 37	58 12	266·1	0·59	3	3·0 6·5	·391	L.
			261·5	0·60	1	...	·468	W.B.
			261·7	0·63	2	...	·486	L.
			259·3	0·65	2	...	·597	L.
			260·7	0·55	1	...	·622	W.B.
Σ 2091 ...	16 39	48 37	303·5	0·99	1	7·5 8·0	·613	W.B.
			304·8	1·07	1	...	·663	B.
			303·1	0·89	1	...	·704	L.
De 15 ...	16 40	46 20	323·3	0·52	1	8·0 8·5	·411	L.
			325·0	0·37	1	...	·695	L.
Σ 2094 A.B.	16 40	66 19	74·7	1·23	1	7·3 7·6	·446	B.
A.C.	...	...	312·2	24·83	1	7·3 11·0	·446	B.
Σ 2106 ...	16 46	80 25	306·0	0·36	1	6·7 8·4	·449	L.
Σ 2107 ...	16 48	61 10	307·6	0·31	1	6·7 8·5	·449	L.
Σ 3107 ...	16 53	85 55	98·5	1·41	1	8·5 8·5	·449	L.
Σ 2112 ...	16 55	58 4	263·3	1·87	1	8·5 9·5	·543	L.
Σ 2114 ...	16 57	81 24	160·1	1·06	1	6·5 8·0	·447	L.
			155·6	1·04	2	...	·504	W.B.
Σ 2118 ...	16 57	24 50	27·4	0·18	1	5·5 6·5	·528	B.
β 357 ...	17 1	79 19	113·5	1·18	1	8·4 9·4	·449	L.
			113·9	1·18	1	...	·561	W.B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
β 823 ...	17 1	89 13	8·8	1·09	1	8·7 9·5	·449	L.
Σ 2130 ...	17 3	35 24	326·6	2·21	1	5 5	·528	B.
Σ 2140 (α Herculis)	17 10	75 30	115·9	4·78	4	3·0 6·1	·569	L.
			112·9	4·75	1	...	·605	B.
OΣ 327 ...	17 12	33 45	305·0	0·17	1	7·6 8·0	·528	B.
β 628 ...	17 15	57 14	358·5	0·42	1	8·7 9·3	·411	L.
			2·0	0·47	1	...	·650	B.
β 629 ...	17 15	57 50	340·6	1·08	2	8·4 8·7	·480	L.
β 45 ...	17 15	...	286·8	4·54	1	...	·624	W.B.
			292·1	5·12	1	...	·663	B.
Swift ...	17 15	36 11	320·8	0·43	1	8·9 9·0	·528	B.
β 630 ...	17 17	57 36	220·9	1·40	1	8·5 9·6	·549	L.
β 1250 ...	17 21	59 9	65·5	1·82	2	9·4 9·5	·545	L.
Σ 2173 ...	17 25	90 56	328·1	1·07	1	5·8 6·3	·534	W.B.
			331·5	0·96	1	...	·570	L.
			334·4	1·17	1	...	·680	B.
OΣ 331 ...	17 26	87 1	333·9	0·91	2	8 9	·551	W.B.
			336·5	0·75	1	...	·570	L.
β 1201 ...	17 27	...	343·3	0·31	1	...	·512	B.
β 1121 ...	17 33	77 24	232·8	0·54	2	8·5 9·0	·589	L.
β 631 ...	17 35	90 35	60·8	0·47	1	7·5 7·6	·681	B.
Σ 2192 ...	17 36	60 43	62·2	5·06	1	7·3 10·2	·457	W.B.
Σ 2199 ...	17 37	34 12	84·5	1·66	2	7 8	·548	B.
Σ 2207 ...	17 38	22 56	129·5	0·74	1	8·0 8·5	·506	B.
Σ 2203 ...	17 38	48 18	314 8	0·75	1	7·5 7·8	·772	B.
β 1251 ...	17 38	73 59	60·3	1·21	2	6·0 11·5	·589	L.
Σ 2206 ...	17 40	70 59	246·8	0·95	1	8·1 9·7	·446	W.B.
Σ 2218 ...	17 40	26 22	343·2	1·71	1	7·8 7·8	·512	W.B.
			349·8	1·91	1	...	·523	B.
Σ 2205 ...	17 41	72 15	304·2	2·06	1	8·3 8·6	·457	W.B.
			306·1	2·20	1	...	·528	L.
Σ 2215 ...	17 42	72 16	288·4	0·58	2	6 8	·568	L.
			285·6	0·74	2	...	·576	W.B.
Hough 70 ...	17 42	59 25	111·6	0·37	1	8 8	·772	B.
Σ 2222 ...	17 43	75 8	58·0	2·18	1	7 8·5	·457	B.
Σ 2228 ...	17 45	...	343·2	1·71	1	...	·506	B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No of Nights.	Mags.	Epoch 1899.	Obs.
OΣ 338 ...	17 47	74 39	20·6	0·65	1	6·5 7·0	·570	L.
			15·5	0·56	1	...	·695	W.B.
			18·2	0·50	1	...	·772	B.
A.C. 9 ...	17 50	60 10	235 1	1·11	1	8·4 8·7	·772	B.
Ho. 72 A.B.	17 52	56 33	1·3	7·23	1	9 11	·723	L.
A.C.	...	...	33·2	9·35	1	9 13	·723	L.
Σ 2258 ...	17 54	41 22	223·0	2·24	1	8·5 8·7	·865	L.
β 1125 ...	17 57	88 40	18·2	0·77	1	5·0 8·5	·608	L.
Σ 2262 (T Ophiuchi)	17 58	98 11	258·9	1·93	3	5 6	·617	B.
Σ 2267 ...	17 58	49 49	65·1	0·97	1	8·5 8·7	·372	L.
			63·1	1·15	1	...	·737	B.
β 1127 ...	17 59	45 47	141·7	0·76	1	7 8 9·7	·865	L.
* ...	18 0	45 47	134·3	0·53	1	8·9 9·0	·372	L.
			130·8	0·34	2	...	·677	B.
A.C. 15 ... (99 Herculis)	18 3	59 27	309·5	0·98	1	6·0 11·0	·608	L.
Σ 2281 ...	18 4	86 2	239·5	0·41	2	5·7 7·2	·684	B.
Σ 2283 ...	18 4	83 52	81·0	0·92	3	7·2 7·7	·479	W.B.
			82·5	0·81	1	...	·648	B.
Σ 2289 ...	18 5	73 32	231·8	0·99	4	6·5 7·0	·523	W.B.
			230·9	1·22	1	...	·630	B.
Σ 2294 ...	18 9	89 51	107·7	0·37	1	7·4 7·7	·630	B.
OΣ 341 ...	18 2	68 34	280·9	0·17	1	7 0 7·5	·772	B.
Σ 2292 ...	18 7	62 23	262·7	1·21	1	8·0 8·1	·446	W.B.
			265·7	1·18	1	...	·548	L.
β 1091 ...	18 9	51 26	38·6	0·28	1	8·6 8·6	·772	B.
β 1274 B.C.	18 13	33 27	103·4	0·72	1	9·8 10·6	·405	L.
B.D.	...	...	7·6	4·38	1	9·8 10·4	...	
β 641 ...	18 17	68 33	344·2	0·90	3	7·3 9·0	·519	W.B.
			351·0	0·90	1	...	·570	L.
			191·5	2·44	1	...	·457	W.B.
β 1203 ...	18 21	89 15	59·0	0·31	1	7·5 7·7	·630	B.
Σ 2315 ...	18 21	62 39	198·3	0·30	2	7·5 9·0	·586	L.
OΣ 543 ...	18 23	43 11	124·8	1·14	1	8·0 10·0	·616	B.
			134·3	1·02	1	...	·695	W.B.
OΣ 351 ...	18 23	41 19	21·8	0·65	1	7·0 7·0	·411	L.
			22·2	0·58	1	...	·616	B.
Σ 2323 ...	18 23	31 16	0·8	3·20	1	4·7 7·7	·528	B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
OΣ 354 ...	18 26	83 18	171·9	0·95	1	7 8	·611	W.B.
			170·1	0·90	3	...	·623	B.
OΣ 357 ...	18 31	78 24	246·8	0·49	3	8·2 8·2	·600	W.B.
			244·5	0·32	3	...	·645	B.
OΣ 358 ...	18 31	73 12	192·4	1·89	1	7·0 7·5	·611	W.B.
			192·4	1·77	3	...	·617	B.
Σ 2356 ...	18 34	61 23	57·4	1·12	2	8·2 8·6	·628	W.B.
* ...	18 34	61 18	253·9	1·18	2	9·0 10·0	·628	W.B.
Hough 87 ...	18 34	73 34	102·5	0·30	2	7·8 8·1	·681	W.B.
			102·2	0·36	1	...	·772	B.
Σ 2367 A.B.	18 37	59 48	258·8	0·22	3	7·2 7·6	·540	L.
			255·9	0·30	1	...	·622	W.B.
A.C.	...	...	193·0	14·23	1	7·2 8·2	·608	L.
Hough 437	18 37	58 27	104·0	0·34	1	8 8	·772	B.
Σ 2384 ...	18 39	22 58	304·8	0·40	1	8·0 8·2	·506	B.
			312·6	0·59	1	...	·512	W.B.
Σ 2369 ...	18 39	87 30	89·7	0·91	1	8 8	·693	B.
Σ 2400 A.B.	18 44	73 51	185·9	0·29	2	8·0 11·1	·526	L.
A.C.	...	...	185·8	3·24	2	8·0 11·0	·526	L.
Σ 2402 ...	18 45	79 25	206·1	0·82	4	8·0 8·4	·500	W.B.
			203·3	1·05	1	...	·648	B.
Σ 2409 ...	18 47	76 35	29·4	1·11	1	8·0 9·3	·611	W.B.
Σ 2410 ...	18 47	30 49	93·8	1·48	1	8·2 8·7	·528	B.
Σ 2412 ...	18 48	76 8	54·1	1·30	1	8·4 8·5	·611	W.B.
β 137 ...	18 50	52 45	131·4	1·27	1	8·2 11·5	·444	L.
* ...	18 50	55 30	84·6	5·13	1	8·0 10 0	·444	L.
Σ 2415 ...	18 51	69 32	288·4	1·69	1	6·6 8·5	·611	L.
β 648 ...	18 53	57 16	222·4	0·96	1	6·0 9·2	·444	L.
Σ 2422 ...	18 53	63 54	95·2	0·66	2	7·9 8·2	·504	L.
			90·8	0·80	2	...	·548	W.B.
β 649 ...	18 55	57 40	9·0	1·91	1	8·2 10·6	·444	L.
Σ 2438 ...	18 56	31 56	211·3	0·32	2	7·2 7·7	·430	L.
			212·1	0·27	1	...	·528	B.
Σ 2437 ...	18 57	70 59	60·8	0·70	2	7·8 8·2	·548	W.B.
Σ 2451 ...	19 1	38 36	69·8	2·05	1	8·7 9·0	·537	L.
Σ 2454 ...	19 2	59 43	248·9	0·95	1	8 9	·605	B.
			241·6	0·91	2	...	·616	W.B.
Σ 2478 ...	19 3	20 43	303·2	1·16	2	8·8 8·8	·518	W.B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 2455 ...	19 3	67 59	79·8	3·22	2	7 8	·611	B.
Hough 98 ...	19 4	62 2	322·9	0·36	2	8 8	·572	L.
			323·7	0·35	2	...	·575	W.B.
			320·5	0·32	1	...	·605	B.
* ...	19 5	63 13	78·7	0·84	1	8·5 10	·572	L.
			79·7	1·11	1	...	·575	W.B.
			72·8	1·14	1	...	·605	B.
Σ 2464 ...	19 5	78 15	23·9	1·09	1	8·2 10·5	·578	W.B.
β 1204 ...	19 7	87 33	12·1	0·37	3	7·7 8·5	·716	B.
OΣ 368 A.B.	19 11	74 1	213·7	0·82	3	8 9	·585	W.B.
			210·3	0·80	2	...	·600	L.
A.C.	...	...	101·7	17·72	1	...	·611	W.B.
OΣ 371 ...	19 12	62 42	150·5	0·77	1	7 7	·534	W.B.
			156·6	0·75	1	...	·580	L.
Σ 2490 ...	19 13	93 37	243·3	3·03	1	8·5 10·7	·791	B.
Σ 2491 ...	19 13	61 52	218·7	0·95	1	7·9 9·2	·611	W.B.
			216·4	0·85	1	...	·717	L.
H.A.II. 95...	19 15	87 14	150·9	0·27	1	6·0 6·5	·630	B.
			149·0	0·50	2	...	·681	W.B.
			147·7	0·48	1	...	·745	L.
β 141 ...	19 18	67 42	81·5	0·89	1	7·5 8·5	·567	W.B.
β 1129 ...	19 19	37 50	343·0	0·28	1	6·3 6·3	·772	B.
Σ 2525 ...	19 22	62 52	317·2	0·42	3	8·0 8·0	·617	W.B.
			319·9	0·46	4	...	·680	L.
			314·4	0·39	1	...	·772	B.
Σ 2536 ...	19 26	72 25	74·8	1·77	1	8 11	·605	B.
* ...	19 27	72 10	344·0	11·32	1	10·5 11	·605	B.
β 438 A.B.	19 28	53 32	37·0	4·59	1	8·0 12·7	·746	L.
C.D.			53·9	5·92	1	7·9 8·3	·746	L.
A.E.			235·3	21·74	1	8·0 12·8	·746	L.
Σ 2539 ...	19 28	61 57	361·2	5·44	1	7·9 9·7	·533	B.
β Cygni ...	19 28	62 15	55·2	34·19	2	3 7	·675	L.
OΣ 375 ...	19 30	72 7	144·6	0·39	3	8·0 9·0	·569	W.B.
Σ 2544 ...	19 32	81 56	208·4	0·77	1	8 10	·643	W.B.
			206·8	1·03	1	...	·739	L.
			209·3	1·12	1	...	·791	B.
Σ 2553 ...	19 33	28 10	115·2	0·83	1	8 9	·523	W.B.
			97·4	0·94	1	...	·529	B.

Star's Name.	R.A. 1900.	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch 1899.	Obs.
	h m	° ′	°	″				
Σ 2556 ...	19 35	68 0	145·2	0·43	4	7 8	·560	W.B.
β 1132 ...	19 39	63 18	225·4	0·40	2	8·3 8·7	·589	W.B.
			221·5	0·43	5	...	·662	L.
✶	19 39	63 18	346·0	3·27	1	9·0 9·5	·580	L.
			344·3	3·54	1	...	·611	W.B.
β 658 ...	19 40	62 9	286·6	0·47	3	6·7 9·7	·696	L.
			290·0	0·60	2	...	·725	W.B.
Σ 2574 ...	19 40	27 35	336·6	0·43	1	8·0 9·0	·528	B.
Σ 2579 (δ Cygni)	19 42	45 7	125·0	1·32	1	3 8	·772	B.
Σ 2592 ...	19 42	13 40	295·9	1·22	1	8·0 9·9	·528	B.
Σ 2585 A.C. (ζ Sagittæ)	19 44	71 7	309·0	8·57	2	4·5 8·0	·679	L.
			308·6	8·42	1	...	·687	W.B.
A.G.C. 11	...	...	159·2	0·22	2	4·5 6·0	·679	L.
A.B.			166·1	0·25	1	...	·687	W.B.
Hough 506	19 45	...	271·9	0·72	2	8 8·1	·573	W.B.
Σ 2597 ...	19 50	97 0	84·6	1·42	3	6·9 8·0	·726	B.
Σ 2600 ...	19 51	67 46	57·9	2·76	2	8·3 9·7	·633	W.B.
β Aquilæ ...	19 51	83 52	12·5	12·45	1	3 12	·791	B.
η Cygni ...	19 53	55 12	214·5	7·54	1	4·0 13·0	·739	L.
β 425 ...	19 53	69 59	241·7	1·36	2	8·4 8·5	·611	B.
			238·5	1·30	1	...	·619	L.
			243·9	1·28	1	...	·622	W.B.
A.C. 16 ...	19 54	63 2	55·5	0·50	2	7 9	·616	W.B.
			57·8	0·40	1	...	·616	B.
			55·2	0·32	1	...	·619	L.
Σ 2607 A.D.	19 54	48 0	296·5	0·30	1	7 9	·739	L.
A.C.	...	...	289·6	2·91	1	7 9	·739	L.
β 1133 ...	19 56	58 27	340·7	0·76	2	6·8 9·5	·745	L.
			338·5	1·00	1	...	·775	W.B.
β 1258 ...	19 56	60 23	161·3	1·42	2	8·0 10·7	·668	L.
			156·8	1·03	1	...	·797	W.B.
✶	19 55	60 23	129·7	3·70	1	9 9·5	·717	L.
Σ 2616 ...	19 58	75 42	266 0	3·73	1	6·8 9·7	·797	W.B.
Σ 2620 ...	20 0	78 30	285·2	1·60	3	8·2 9·3	·655	W.B.
Σ 2624 A.B.	20 0	54 16	174·9	1·89	1	7·2 7·8	·797	W.B.
A.C.	...	...	172·1	29·02	1	7·2 9·5	·297	W.B.
A.D.	...	...	328·2	42·50	1	7·2 10·0	·297	W.B.
Σ 2642 ...	20 5	26 36	352·7	2·16	1	8·7 8·7	·528	B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position. Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 2652 ...	20 8	28 12	76·2	0·26	1	7·5 7·7	·528	B.
Σ 2695 ...	20 28	64 39	75·5	0·99	2	6·2 8·0	·581	L.
			74·0	0·99	2	...	·661	W.B.
β 151 A.B. (β Delphini)	20 33	75 46	6·8	0·43	2	4·5 6·0	·623	B.
			6·4	0·41	4	...	·683	W.B.
			5·6	0·56	3	...	·721	L.
β 151 A.C.	...	...	116·2	25·60	1	4·5 11·0	·630	B.
A.D.	...	...	331·7	37·25	1	4 11	·630	B.
β 64	20 40	77 40	189·4	0·48	1	8·3 8·3	·630	B.
			182·9	0·46	5	...	·646	W.B.
Σ 2729	20 46	96 4	198·2	0·24	1	6 7	·630	B.
β 367	20 51	62 18	128·2	0·46	2	8·0 8·6	·681	W.B.
			133·2	0·45	4	...	·732	L.
Barnard ...	20 52	86 27	86·2	1·44	1	10·1 11·3	·791	B.
OΣ 424 ...	20 54	74 50	321·1	0·44	3	8·0 9·3	·630	B.
			328·7	0·39	1	...	·671	L.
β 69 ...	20 58	68 43	308·2	1·01	2	8·3 9·1	·675	W.B.
Σ 2737 A.B. (ε Equulei)	20 54	86 7	286·2	0·62	1	5·7 6·2	·761	L.
			284·1	0·55	1	...	·764	W.B.
			279·3	0·77	1	...	·791	B.
A.C.	...	...	72·8	10·46	1	5·7 7·1	·764	W.B.
			72·9	10·59	1	...	·291	B.
β 156 ...	20 58	43 50	241·3	1·03	1	7·5 9·9	·780	B.
			247·8	1·01	1	...	·792	W.B.
			247·6	0·96	1	...	·865	L.
Σ 2744 ...	20 58	88 51	159·2	1·35	1	6·5 7·5	·764	W.B.
			166·2	1·36	2	...	·782	B.
			167·0	1·42	1	...	·827	L.
Σ 2749 A.B.	21 0	86 52	156·7	2·71	2	7·7 8·9	·694	B.
			152·9	2·92	1	...	·827	L.
A.D.	...	...	152·9	0·58	1	7·7 8·9	·827	L.
B.C.	...	...	156·9	1·18	2	8·9 10·0	·694	B.
			149·9	1·10	1	...	·827	L.
OΣ 527 ...	21 4	85 17	97·4	0·38	2	7 8·5	·696	B.
			110 9	0·66	1	...	·764	W.B.
Hough 152	21 8	62 7	324·7	0·60	3	8·5 9 5	·668	W.B.
τ Cygni ...	21 10	52 24	307·2	0·60	1	3 9 10·0	·865	L.

Star's Name.	R.A. 1900. h m	N.P.D. 1900 ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
OΣ 535 ...	21 10	80 27	201·7	0·17	1	4·1 4·1	·630	B.
			190·3	0·23	1	...	·761	L.
			191·9	0·28	1	...	·770	W.B.
β 163 ...	21 13	78 52	249·7	0·69	1	7 10	·630	B.
			255·5	0·69	2	...	·841	W.B.
β 838 ...	21 15	87 20	95·7	1·38	2	8 9	·711	B.
β 1212 ...	21 34	90 33	267·8	0·49	2	6·5 6·9	·696	B.
			261·6	0·51	1	...	·775	W.B.
Hough 165	21 38	71 29	72·0	0·41	2	8 8·2	·725	W.B.
A.B.	...	...	68·5	0·47	3	...	·808	L.
A.C.	...	...	21·7	20·29	2	...	·837	L.
Σ 2822 ...	21 39	61 43	125·4	2·65	2	4 5	·734	L.
Σ 2824 A.C. (κ Pegasi)	21 40	64 51	298·1	12·44	3	3·9 10·8	·788	L.
β 989 A.B.	...	...	278·3	0·17	2	3·9 5·0	·575	L.
			281·4	0·21	2	...	·720	L.
			271·4	0·19	3	...	·767	L.
			274·6	0·15	1	...	·797	W.B.
			269·2	0·20	2	...	·836	L.
Hough 166	21 40	62 38	99·8	0·42	1	7·5 7·5	·687	W.B.
			97·8	0·41	2	...	·734	L.
Σ 2825 ...	21 42	89 38	117·8	0·83	1	8 9	·846	L.
Hough 171	21 48	62 41	173·7	0·61	2	8 8	·720	L.
β 75 ...	21 50	79 35	42·3	0·96	3	8·1 8·3	·754	W.B.
			38·2	1·16	2	...	·786	B.
			40·1	0·90	1	...	·832	L.
Σ 2849 ...	21 53	76 19	261·1	1·51	2	8·2 10·7	·656	W.B.
Hough 176	21 57	66 56	183·9	0·93	2	8 11	·671	W.B.
Hough 179	22 8	60 28	258·5	0·47	3	8·0 8·5	·727	W.B.
			254·9	0·45	1	...	·780	B.
Σ 2878 ...	22 9	82 33	125·7	1·02	1	6·5 8·0	·791	B.
Σ 2881 ...	22 10	60 57	96·5	1·58	2	7·7 8·2	·671	W.B.
			98·1	1·56	2	...	·737	L.
Hough 180	22 12	46 38	224·2	0·60	1	7·0 7·5	·865	L.
β 1216 ...	22 15	61 0	307·3	0·53	2	8·4 8·7	·704	W.B.
			308·7	0·49	2	...	·736	L.
			308·5	0·55	1	...	·780	B.
β 172 ...	22 19	95 23	10·6	0·68	2	5·6 6·0	·755	B.

Star's Name.	R.A. 1900. h m	N.P.D. 1900. ° ′	Position. Angle. °	Distance. ″	No. of Nights.	Mags.	Epoch 1899.	Obs.
Σ 2900 ...	22 19	69 40	171·4	1·23	3	6·0 9·2	·760	W.B.
β 291 A.B.	22 23	86 0	175·0	0·31	1	8·4 8·7	·630	B.
			168·5	0·34	1	...	·761	L.
A.C.	...	...	125·0	31·90	1	8·4 10·0	·761	L.
β 1218 ...	22 23	60 50	53·3	1·42	1	8·6 8·8	·654	W.B.
			54·6	1·49	2	...	·737	L.
			51·1	1·54	1	...	·780	B.
Σ 2912 (37 Pegasi)	22 25	86 6	110·2	0·34	1	6·5 7·8	·737	B.
			108·0	0·30	1	...	·761	L.
Hough 296	22 36	75 59	75·7	0·43	1	5·5 5·5	·775	W.B.
			277·7	0·42	1	...	·846	L.
Σ 2934 ...	22 37	69 6	144·4	0·88	4	8·2 9·2	·671	W.B.
β 710 ...	22 38	60 50	232·3	0·42	2	8·0 8·5	·737	L.
			234·3	0·42	1	...	·764	W.B.
			235·0	0·42	1	...	·780	B.
β 144 ...	22 38	60 18	85 9	0·31	1	10 10	·723	L.
			81·1	0·36	1	...	·906	W.B.
β 711 ...	22 40	79 20	44·5	1·07	1	9 10	·780	B.
			52·0	0·75	1	...	·870	W.B.
			55·1	0·58	1	...	·846	L.
Σ 2944 ...	22 42	94 47	256·3	3·11	1	7·0 7·5	·780	B.
β 1037 ...	22 43	77 32	232·3	0·69	1	8·5 10·5	·846	L.
β 1146 ...	22 44	59 26	329·6	0·27	1	7·2 8·2	·780	B.
			316·2	0·20	1	...	·817	L.
β 382 ...	22 49	45 47	226 8	0·79	1	7·3 8·8	·780	B.
			232·0	0·75	1	...	·893	L.
OΣ 536 A.B.	22 53	81 10	230·0	0·24	1	7·3 7·4	·846	L.
A.C.	...	...	241·0	15·64	1	7·3 10·0	·846	L.
OΣ 483 ...	22 54	78 48	222·0	0·53	3	6·0 7·5	·745	W.B.
β 1025 ...	23 9	77 53	266·2	0·84	1	8·0 10·8	·654	W.B.
β 79 ...	23 12	92 5	83·3	0·84	1	8 8·5	·772	B.
			88·0	0·44	1	...	·775	W.B.
Σ 2995 ...	23 12	92 8	33·2	5·01	1	7·7 8·0	·025	B.
β 80 ...	23 14	85 10	343·8	0·45	1	8 8·5	·025	B.
			350·3	0·42	2	...	·755	B.
β 1222 ...	23 23	87 0	40·0	1·33	2	9 9	·755	B.
β 1266 ...	23 25	59 43	228·7	0·22	1	7·2 7·5	·861	L.

Star's Name.	R.A. 1900.	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Mags.	Epoch 1899.	Obs.
	h m	° ′	°	″				
β 720 ...	23 29	59 14	157·4	0·33	3	5·5 5·5	·779	W.B.
			163·9	0·31	1	...	·780	B.
			162·1	0·38	3	...	·813	L.
β 858 ...	23 36	58 0	267·7	0·58	1	8·0 8·2	·780	B.
			260·1	0·52	2	...	·831	L.
A.G.C. 14 ...	23 39	61 12	194·3	1·23	1	5·5 9·7	·780	B.
			196·9	1·28	1	...	·830	W.B.
			196·9	1·25	2	...	·834	L.
Σ 3037 ...	23 41	30 5	213·7	2·67	1	7·0 8·5	·068	B.
Barnard ...	23 42	85 18	166·8	0·62	1	8·6 8·6	·737	B.
Σ 3047 ...	23 54	33 10	72·5	1·26	1	8·7 8·7	·068	B.
Σ 3050 ...	23 54	56 51	214·3	2·37	1	6·0 6·0	·797	W.B.
			214·3	2·40	1	...	·832	L.
Σ 3056 ...	23 59	56 20	153·7	0·40	1	7 8	·893	L.

Measures of Double Stars from Photographs taken at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The photographs were taken with the 26-inch refractor of the Thompson Equatorial, the stars photographed being either bright stars with faint companions, or selected double stars which seemed well suited for photographic measurement. For the former an occulting shutter, carried by an arm pivoted in the side of the dark slide, was used to screen the bright star, a series of short intermittent exposures for it being given during the long exposure required for the companion by raising the arm of the shutter by hand and allowing it to fall back into position again as rapidly as practicable. In order to allow of still shorter exposures in the case of very bright objects a useful modification was introduced by Mr. Davidson. In the new arrangement the shutter consists of two parts separated by a narrow slit, so that the exposure is given only during the rapid passage of the slit across the star's image, and by this device it is found practicable to give exposures of about $0^s{\cdot}01$ only in duration.

The exposures given to the photographs were, as far as possible, such as would give small and sharp images; for bright pairs dry collodion plates were sometimes used, but for stars with faint companions Ilford special rapid plates were used. A second exposure was given for orientation, the clock being put out of

gear for about 10^s, and sometimes two subsidiary exposures of this kind were given as a check.

The photographs were measured in a position-micrometer by two measurers, being measured by each in reversed positions of the plates to eliminate personality.

Details are given in the case of *β Persei*, *Aldebaran*, and *ξ Ursæ Majoris* to indicate the accuracy obtainable in double star observations from photographs. The main part of the discordances appears to be due to the photographic images themselves and not to error of measurement. Much higher accuracy is obtainable with stars such as *ξ Ursæ Majoris*, *γ Virginis*, &c., than with stars like *Aldebaran*, where the companion is very faint.

β Persei.—These results are obtained from three photographs taken on October 11, October 17, and November 10. On October 11 and October 17 exposures of 20^m were given to the faint companions, and a single exposure of about $\frac{1}{2}^s$ to *Algol*. On November 10, twenty short exposures were given to *Algol* of about $\frac{1}{100}^s$ each at intervals of 1^m during the 20^m exposure on the field, Mr. Davidson's new arrangement of the occulting shutter being used. The sums of the projections of the sides of the two closed triangles ABC and ADE revolved in the directions 0° and 90° are $-0''{\cdot}02$, $-0''{\cdot}05$ for ABC, and $+0''{\cdot}02$, $+0''{\cdot}09$ for ADE, which furnish a sufficient test of the accuracy of the measures.

Aldebaran.—The first set of results is obtained from photographs taken on 1899 February 24, March 9, March 14, and March 15. On two of these photographs a single short exposure was given to the primary, and an exposure of 20^m to the companions. On the other two five short exposures were given to the primary.

The second set of results depends on four photographs taken 1899 November 10, 1900 January 18, January 24, and February 9. These were taken with the occulting shutter after its alteration, and at each minute of the 20^m exposure of the faint stars a short exposure (estimated from the size of the image at $\frac{1}{100}^s$) was given to *Aldebaran*, which thus had a total exposure of about $\frac{1}{5}^s$. The following individual results for A and B are given as showing the accuracy attained in these photographs :—

Date.	Measurer.	Angle.	Discordance from Mean.	Distance.	Discordance from Mean.
1899 Nov. 10	C.D.	109°84	+0°10	31″73	+0″16
,,	P.M.	109·42	−0·32	31·79	+0·22
1900 Jan. 18	C.D.	109·45	−0·29	31·35	−0·22
,,	P.M.	109·82	+0·08	31·23	−0·34
Jan. 24	C.D.	109·97	+0·23	31·54	−0·03
,,	P.M.	110·25	+0·51	31·60	+0·03
Feb. 9	C.D.	109·95	+0·21	31·65	+0·08
,,	P.M.	109·25	−0·49	31·65	+0·08

ξ Ursæ Majoris.—The separate observations of this star are as follows :—

Date.	Measurer.	Angle.	Discordance from Mean.	Distance.	Discordance from Mean.
		°	°	″	″
1899 Apr. 11	C.D.	159·39	+2·4	1·89	−0·04
„	P.M.	162·03	+5·1	1·95	+0·02
Apr. 17	C.D.	156·35	−0·6	1·95	+0·02
„	P.M.	156·29	−0·7	1·94	+0·01
Apr. 19	C.D.	156·43	−0·5	1·92	−0·01
„	P.M.	157·53	+0·6	1·87	−0·06
May 3	C.D.	152·95	−4·0	1·93	0·00
„	P.M.	154·68	−2·3	1·98	+0·05

Ilford "Empress" plates were used for the first three of these days, and a Hill-Norris' dry collodion "Gazelle" plate on May 3. For the "Empress" plates several exposures were given on each plate, varying from $\frac{1}{5}^{s}$ to 1^{s}, and for the "Gazelle" plate from $\frac{1}{2}^{s}$ to 5^{s}.

Name of Star.		R.A. 1900·0.	N.P.D. 1900·0.	Mags.	Position Angle.	Distance.	Epoch.	Number of Photos.	Number of Images.
		h m	° ′		°	″			
β Persei	AB	3 2	49 26	... 13·5	155·29	58·24	1899·820	3	3
	AC	...	...	... 14·2	145·58	67·47	1899·820	3	3
	AD	...	...	3 11·0	192·65	81·73	1899·820	3	3
	AE	...	...	... 12·5	185·39	85·69	1899·820	3	3
	BC	...	...	13·5 14·2	101·16	14·05	1899·820	3	3
	DE	...	...	11·0 12·5	119·48	11·26	1899·820	3	3
Aldebaran	AB	4 30	73 42	1·0 14·2	109·80	31·73	1899·182	4	4
	AC	...	...	1·0 10·6	...	117·89	1899·182	4	4
	AC	...	...	..	34·36	...	1899·199	2	2
	AB	...	...	1·0 14·2	109·74	31·57	1900·019	4	4
	AC	...	...	1·0 10·6	34·09	118·27	1900·019	4	4
Castor ...	....	7 28	57 53	2·7 3·7	226·32	6·15	1899·219	1	5
Pollux ...	...	7 39	61 44	1·1 14·3	280·05	29·65	1900·076	2	2
α Cancri...	...	8 53	77 45	4·3 11·2	147·61	11·40	1899·197	1	3
ξ Ursæ Maj.	...	11 13	57 54	4·0 4·9	156·96	1·93	1899·298	4	13
γ Virginis	...	12 36	90 52	3·0 3·0	149·59	5·73	1899·319	4	16
ζ Ursæ Maj.	...	13 20	34 33	2·6 4·2	149·69	14·42	1899·290	1	5
ε Boötis...	...	14 38	62 29	3·0 6·3	326·71	2·60	1899·285	3	11
σ Coronæ Bor.	...	16 11	55 53	5·0 6·1	212·97	4·38	1899·531	1	12
α Herculis	AB	17 10	75 30	3·0 6·1	114·50	4·75	1899·468	2	7
	AC	...	...	3·0 15	334·85	24·07	1899·523	1	1

Name of Star.		R.A. 1900·0.	N.P.D. 1900·0.	Mags.	Position Angle.	Distance.	Epoch.	Number of Photos.	Number of Images.
		h m	° ′		°	″			
τ Ophiuchi	...	17 58	98 11	5·0 6·0	256·42	1·71	1899·567	1	8
OΣ 358	...	18 31	73 6	6·5 7·0	194·48	1·73	1899·567	1	6
α Lyræ	...	18 33	51 19	1 14	285·07	54·36	1899·580	1	1
ε Lyræ	...	18 41	50 30	5·0 6·5	11·64	3·08	1899·580	1	7
5 Lyræ	...	...	...	5·1 5·2	127·57	2·35	1899·580	1	6
β 650	AB	19 27	83 43	8·1 11·6	148·56	6·80	1899·635	1	1
	AD	...	...	8·1 10·0	254·38	27·04	1899·635	1	1
	AC	...	...	8·1 13·0	327·52	11·43	1899·635	1	1
β 438	AB	19 28	53 32	8·0 12·7	31·25	4·63	1899·775	1	1
	AC	...	...	8·0 8·2	247·89	46·80	1899·705	2	4
	AD	...	...	8·0 8·2	246·23	52·63	1899·705	2	4
	AE	...	...	8·0 12·8	237·63	21·18	1899·705	2	2
	CD	...	...	8·2 8·2	53·20	6·03	1899·705	2	4
β 659	...	19 50	83 8	6·6 12·5	313·67	12·96	1899·774	2	2
α Delphini	AB	20 35	74 26	4·0 13·5	223·59	29·19	1899·765	2	2
	AC	...	...	4·0 11·1	279·44	43·95	1899·673	3	3
	AD	...	...	4·0 11·5	151·78	47·65	1899·673	3	3
	AE	...	...	4·0 12·7	307·67	51·59	1899·650	2	2
	AF	...	...	4·0 11·0	115·15	79·24	1899·673	3	3
T Cygni	AB	20 43	56 0	5·6 12·2	121·36	10·31	1899·773	2	2
	AC	...	...	5·6 13·3	196·24	12·66	1899·773	2	2
61 Cygni	...	21 2	51 46	5·1 6·0	125·36	21·92	1899·798	4	15
β 449	AB	21 35	48 45	7·1 12·7	13·09	6·20	1899·646	3	3
	AC	...	...	7·1 11·0	171·91	13·91	1899·646	3	3
	AD	...	...	7·1 12·1	247·10	17·43	1899·646	3	3
	AE	...	...	7·1 7·2	44·82	29·03	1899·646	3	3
κ Pegasi	AC	21 40	64 51	3·9 10·8	300·42	12·86	1899·801	5	6
19 Cephei	...	22 2	28 13	5·7 11·5	93·20	20·09	1899·775	2	2
β 698	...	22 7	83 37	6·8 11·0	337·09	10·58	1899·797	3	3
β 377	AB	22 11	35 51	8·0 10·6	66·07	61·81	1899·792	2	3
	AC	...	...	8·0 11·3	60·50	58·30	1899·792	2	3
	AD	...	...	8·0 13·0	264·23	34·88	1899·792	2	3
	AE	...	...	8·0 14·0	260·94	40·09	1899·789	1	1
	AF	...	...	8·0 13·0	112·65	33·54	1899·792	2	2
	BC	...	...	10·6 11·3	303·49	7·07	1899·792	2	3
	DE	...	...	13·0 14·0	241·49	6·07	1899·789	1	1

Royal Observatory, Greenwich:
1900 *April* 10.

Cometary Observations at the Liverpool Observatory. By W. E. Plummer.

Comet 1898 *X* (*Brooks, October* 20).

Greenwich Mean Time of Observation. 1899.				☄ − ✶ R.A.	No. of Comparisons.	Apparent R.A. of ☄.	☄ − ✶ Declination.	No. of Comparisons.	Apparent Declination of ☄.	Log. Factor of Parallax in α.	in δ.	Star of Comparison.
	h	m	s	m s		h m s	′ ″		° ′ ″			
Oct. 24	10	2	14·5	+5 59·67	10	15 55 59·38	−7 23·2	5	+50 36 9·6	+9·6394	−0·8421	1
	10	2	14·5	−3 6·90	10	15 55 59·51	+3 10·2	5	+50 36 8·1	+9·6394	−0·8421	2
30	7	7	22·4	−1 39·18	Ret.	17 0 42·06	+5 52·1	Ret.	+33 26 43·4	+9·6058	−0·7041	3
31	6	58	4·7	−1 14·61	10	17 7 45·22	+2 33·3	6	+30 44 2·1	+9·5840	−0·7122	4
Nov. 1	7	3	27·0	−1 15·16	10	17 14 8·30	−1 53·0	5	+28 6 3·2	+9·5761	−0·7335	5
1	7	3	27·0	−1 30·38	10	17 14 8·32	−5 19·6	5	+28 6 4·9	+9·5761	−0·7335	6
3	6	50	50·1	+ 2·88	Ret.	17 24 56·14	−4 54·5	Ret.	+23 13 54·5	+9·5473	−0·7514	7
6	6	56	34·3	− 40·82	12	17 37 38·66	−2 7·7	6	+16 46 29·6	+9·5332	−0·7912	8
7	6	8	40·5	+ 0·62	Ret.	17 41 0·78	−1 23·4	Ret.	+14 55 4·5	+9·4817	−0·7816	9
10	6	4	33·6	+ 39·47	10	17 49 46·21	−3 54·6	5	+ 9 44 33·6	+9·4731	−0·8087	10
10	6	4	33·6	−1 26·11	8	17 49 46·13	−1 46·0	5	+ 9 44 34·0	+9·4731	−0·8087	11

October 24.—The comet is a fairly bright object, with well-defined centre, which makes the observation easy.
October 30.—The comet seen through some haze with difficulty. The observation is somewhat uncertain.
November 7.—The comet is bright, but very ill-defined, and the observations lack coherence.

Comet 1899 *I* (*Swift, March* 4).

1899.	Greenwich Mean Time of Observation.	☄ − ✶ R.A.	No. of Comparisons.	Apparent R.A. of ☄.	☄ − ✶ Declination.	No. of Comparisons.	Apparent Declination of ☄.	Log. Factor of Parallax in a.	in δ.	Star of Comparison.
	h m s	m s		h m s	′ ″		° ′ ″			
Mar. 7	7 2 59·5	−2 40·70	3	3 33 24·63	+ 1 17·9	3	−23 13 10·7	+9·3358	−0·9121	12
11	7 13 4·6	−1 8·42	2	3 14 58·34	+ 2 38·9	2	−17 50 34·0	+9·4198	−0·8935	13
12	7 15 2·9	−1 39·36	3	3 10 53·80	+ 5 21·0	3	−16 35 51·6	+9·4666	−0·8831	14
14	7 9 6·0	+ 43·37	5	3 3 16·55	− 5 26·1	5	−14 14 5·2	+9·4460	−0·8830	15
15	7 11 3·1	+2 10·89	5	2 59 39·48	− 4 48·0	5	−13 6 19·4	+9·4582	−0·8804	16
15	7 11 3·1	− 51·09	5	2 59 39·33	+ 49·7	5	−13 6 16·8	+9·4582	−0·8804	17
16	7 12 51·7	+3 23·28	Ret.	2 56 10·10	+ 8 17·0	Ret.	−12 0 44·4	+9·4689	−0·8752	18
17	7 13 22·5	+ 43·74	2	2 52 46·58	−10 22·6	2	−10 57 15·4	+9·4773	−0·8719	19
17	7 13 27·9	+3 31·70	5	2 52 46·51	− 5 58·6	5	−10 57 14·6	+9·4773	−0·8719	20
18	7 20 59·3	+1 32·32	5	2 49 27·92	− 4 8·3	5	− 9 55 32·7	+9·4929	−0·8673	21
20	7 22 6·8	+7 38·38	Ret.	2 43 4·46	− 5 49·1	Ret.	− 7 57 44·9	+9·5055	−0·8618	22
22	7 24 13·7	−6 33·54	Ret.	2 36 55·38	+ 2 3·7	Ret.	− 6 7 29·4	+9·5169	−0·8570	23
May 16	11 22 54·0	+0 39·22	5	22 53 5·16	+ 0 57·7	5	+40 22 30·1	−9·5952	−0·8525	24
18	11 5 36·3	−1 15·54	6	22 34 51·17	− 9 40·5	4	+43 35 11·3	−9·6267	−0·8357	25
18	11 5 36·3	+ 29·05	6	22 34 51·43	−11 55·4	6	+43 35 12·1	−9·6267	−0·8357	26
26	10 16 40·5	−1 1·89	5	20 29 11·40	− 59·9	5	+55 36 16·4	−9·7925	−0·6149	27
27	9 57 29·8	+ 58·57	4	20 6 17·47	+ 4 56·6	4	+56 28 0·3	−9·8025	−0·5893	28
29	11 6 44·2	−3 3·72	5	19 15 23·86	− 6 32·3	5	+57 20 35·0	−9·7411	−0·1600	29
29	11 6 44·2	+3 13·61	5	19 15 23·49	−11 6·9	5	+57 20 38·6	−9·7411	−0·1600	30
30	10 22 0·4	−1 14·88	6	18 50 49·16	− 4 11·4	6	+57 17 11·7	−9·7582	−0·2378	31
31	10 19 13·1	−4 57·28	5	18 25 55·74	− 3 15·7	5	+56 54 44·7	−9·7240	−0·1296	32
31	10 19 13·1	+2 25·14	5	18 25 55·72	− 39·1	5	+56 54 47·1	−9·7240	−0·1296	33

1899. Greenwich Mean Time of Observation.	☄−✶ R.A.	No. of Comparisons.	Apparent R.A. of ☄.	☄−✶ Declination.	No. of Comparisons.	Apparent Declination of ☄.	Log. Factor of Parallax in α.	in δ.	Star of Comparison.
June 1 9 56 58·3	+1 18·65	3	18 2 22·33	− 7 0·7	3	+56 14 54·7	−9·7094	−0·1311	34
2 9 50 11·6	−2 6·19	5	17 39 58·25	+ 6 55·9	5	+55 18 46·9	−9·6698	−0·0746	35
2 9 50 11·6	−1 24·31	5	17 39 57·99	+ 6 23·1	5	+55 18 47·0	−9·6698	−0·0746	36
4 10 11 44·0	+1 0·31	4	16 59 58·70	+ 2 37·5	4	+52 47 29·7	−9·4874	−9·8461	37
5 10 10 29·8	−5 33·28	5	16 42 55·27	+ 1 22·8	5	+51 19 15·6	−9·4032	−9·8645	38
5 10 10 29·8	+ 45·15	5	16 42 55·13	+ 1 38·3	5	+51 19 16·1	−9·4032	−9·8645	39
6 10 14 3·7	+1 54·00	6	16 27 34·80	− 7 53·5	6	+49 45 22·1	−9·2956	−9·9066	40
8 10 24 41·4	−7 36·73	6	16 1 38·70	+ 1 10·9	6	+46 29 42·0	−8·9564	−0·0371	41
8 10 24 41·4	+1 56·62	6	16 1 38·68	+10 41·0	6	+46 29 40·9	−8·9564	−0·0371	42
9 10 3 32·5	+2 20·51	5	15 50 57·44	− 6 51·0	5	+44 53 2·7	−9·0078	−0·1313	43
9 10 3 32·5	+1 27·28	5	15 50 57·39	+ 3 45·4	5	+44 53 3·6	−9·0078	−0·1313	44
10 10 45 11·2	−5 5·52	Ret.	15 41 0·81	+ 4 13·1	Ret.	+43 13 18·3	+8·2304	−0·1838	45
12 10 36 4·0	−1 45·00	6	15 24 42·71	− 8 38·5	6	+40 6 33·3	+8·6720	−0·2993	46
12 10 36 4·0	−1 57·35	6	15 24 42·63	+ 4 12·4	6	+40 6 34·6	+8·6720	−0·2993	47
13 10 21 46·1	−2 43·51	Ret.	15 17 51·60	+ 5 13·4	Ret.	+38 38 4·2	+8·5843	−0·3409	48
14 10 48 59·9	+ 19·83	Ret.	15 11 31·72	− 2 4·5	Ret.	+37 10 8·0	+9·0363	−0·4025	49
15 11 6 22·0	+1 42·16	Ret.	15 5 50·90	+ 9 1·2	Ret.	+35 46 19·2	+9·1912	−0·4531	50
16 10 49 55·3	−2 13·40	Ret.	15 0 51·80	+ 6 35·0	Ret.	+34 27 46·0	+9·1451	−0·4752	51

March 7.—The comet was seen long before any star of comparison could be seen in the light sky of twilight owing to the low altitude; the definition was very unsatisfactory.

March 11–22.—The conditions for seeing very unfavourable; a correction for difference of refraction has been applied.

May 16.—The comet is bright but diffused.

May 27.—Observations interrupted by clouds.

June 10.—Clouds; sky very light.

June 13.—Seen with difficulty.

Tuttle's Comet.

Greenwich Mean Time of Observation.	☄ − ✶ R.A.	No. of Comparisons.	Apparent R.A. of ☄.	☄ − ✶ Declination.	No. of Comparisons.	Apparent Declination of ☄.	Log. Factor of Parallax in α	in δ	Star of Comparison.
1899. h m s	m s		h m s	′ ″		° ′ ″			
Apr. 4 8 11 22·0	+0 19·45	Ret.	3 10 2·37	+ 9 1·2	Ret.	+22 59 26·5	+9·5791	−0·8076	52
10 8 28 16·3	−0 56·81	Ret.	3 32 12·41	+ 6 20·6	Ret.	+20 41 36·0	+9·5737	−0·8178	53

April 4.—The comet appeared as a small round nebula of about one minute in diameter, in which neither condensation nor nucleus could be detected.

April 10.—The comet is at the limit of visibility, and cannot be profitably observed with this instrument.

Comet 1899 *IV* (*Tempel II.*)

Greenwich Mean Time of Observation.	☄ − ✶ R.A.	No. of Comparisons.	Apparent R.A. of ☄.	☄ − ✶ Declination.	No. of Comparisons.	Apparent Declination of ☄.	Log. Factor of Parallax in R.A.	in δ	No. of Reference.
1899. h m s	m s		h m s	′ ″		° ′ ″			
July 26 10 39 12 1	+0 56·76	Ret.	20 46 40·49	+ 2 18·6	Ret.	−21 21 35·7	−9·2816	−0·9136	54
28 12 19 51 2	−1 58 57	Ret.	20 49 8·26	−7 2·2	Ret.	−22 30 18·6	−8·4073	−0·9296	55
30 11 6 30·3	−4 10·63	Ret.	20 51 27·27	−6 22·1	Ret.	−23 34 27·6	−9·1361	−0·9247	56
Aug. 1 11 21 55·8	+2 37 26	Ret.	20 53 50·12	−4 52·0	Ret.	−24 39 32·4	−9·0188	−0·9286	57

July 26.—The comet faint and ill-defined; but seen no better later in the evening, owing to the increase of moonlight.

July 30 and August 1.—The places are very doubtful, and are hardly likely to be of use in future discussion.

Comet 1899 *V* (*Giacobini*).

1899.	Greenwich Mean Time of Observation. h m	✱−✱ R.A. m s	No. of Comparisons.	Apparent R.A. of ✱. h m s	✱−✱ Declination. ′ ″	No. of Comparisons.	Apparent Declination of ✱. ° ′ ″	Log. Factor of Parallax in R.A.	in δ.	No. of Reference.
Oct. 4	7 32 11·3	+6 37·43	Ret	16 35 19 80	−5 58·7	Ret.	− 3 40 39·3	+9·4558	−0·8582	58
8	7 38 9·0	+2 21·97	Ret.	16 41 5 42	+ 46·1	Ret.	− 2 25 40·6	+9·4755	−0·8519	59
9	7 40 50·9	−3 31 42	Ret.	16 42 31·96	−4 44·8	Ret.	− 2 7 16·1	+9·4813	−0·8528	60

October 4.—Heavy mist prevented a good view of the comet, which appeared very faint, and was found with difficulty.
October 8.—The comet better seen than on the 4th inst, but very difficult to observe.

Stars of Comparison. *Comet* 1898 *X* (*Brooks, October* 20).

Date 1898.	Star's Designation or Authority for Places.	Mean R.A. Equinox of Year. h m s	Correction to Mean R.A. s	Mean Declination. Equinox of Year. ° ′ ″	Correction to Mean Declination. ″	No. of Reference.
Oct. 24	A.G.Z. Cambridge, No. 4860	15 49 59·56	+0·15	+50 43 36·4	− 3·6	1
24	Harvard, Zones, No. 871	15 59 6·27	+0·14	+50 33 1·5	− 3·6	2
30	A.G.Z. Leiden, Zones, Nos. 68–207	17 2 19·95	+1·29	+33 20 47·4	+ 3·9	3
31	A.G.Z. Leiden, Zones, Nos. 193–202	17 8 58·40	+1·43	+30 41 24·5	+ 4·3	4
Nov. 1	A.G.Z. Cambridge, No. 8136	17 15 21·91	+1·55	+28 7 51·6	+ 4·6	5
1	A.G.Z. Cambridge, No. 8142	17 15 37·15	+1·55	+28 11 19·9	+ 4·6	6
3	A.G.Z. Berlin B, No. 5993	17 24 51·50	+1·76	+23 18 44·2	+ 4·8	7
6	A.G.Z. Berlin A, No. 6405	17 38 17·47	+2·01	+16 48 32·4	+ 4·9	8
7	A.G.Z. Leipzig and Berlin A, No. 6421	17 40 58·07	+2·09	+14 56 22·9	+ 5·0	9
10	A.G.Z. Leipzig Zones	17 49 4·50	+2·24	+ 9 48 23·9	+ 4·3	10
10	Paris Catalogue, No. 23034	17 51 9·98	+2·26	+ 9 46 15·4	+ 4·6	11

Comet 1899 *I* (*Swift*, *March* 4).

Date 1899.	Star's Designation or Authority for Places.	Mean R.A. Equinox of Year. h m s	Correction to Mean R.A. s	Mean Declination. Equinox of Year. ° ′ ″	Correction to Mean Declination. ″	No. of Reference.
Mar. 7	A.We., No. 2019	3 36 4·41	+0·92	−23 14 21·9	− 6·7	12
11	A.We., No. 1819; Paris, No. 3997	3 16 5·93	+0·83	−17 53 8·6	− 4·3	13
12	A.We., No. 1791	3 12 32·37	+0·81	−16 41 8·7	− 3·9	14
14	Porter (12), No. 214; Stone, No. 744	3 2 32·40	+0·78	−14 8 36·3	− 2·8	15
15	Stone, No. 727	2 57 27·83	+0·76	−13 1 29·1	− 2·3	16
15	W.B. II., No. 1038	3 0 29·65	+0·77	−13 7 4·1	− 2·4	17
16	W.B. II., No. 886; La_3, No. 230	2 52 46·07	+0·75	−12 8 59·5	− 1·9	18
17	W.B. II., No. 875; La_3, No. 229	2 52 2·09	+0·75	−10 46 51·3	− 1·5	19
17	Stone, Rad. Cat., No. 690	2 49 14·06	+0·75	−10 51 14·4	− 1·6	20
18	Paris, No. 3528; Stone, No. 684	2 47 54·87	+0·73	− 9 51 23·4	− 1·0	21
20	Stone, Rad. Cat., No. 636	2 35 25·38	+0·70	− 7 51 55·5	− 0·3	22
22	Stone, Rad. Cat., No. 668	2 43 28·23	+0·69	− 6 9 33·3	+ 0·2	23
May 16	A.G.Z. Bonn Cat., No. 17271	22 52 24·48	+1·46	+40 21 35·0	− 2·6	24
18	11 Lacertæ, A.G.Z. Bonn Cat., No. 16991	22 36 5·17	+1·54	+43 44 55·5	− 3·7	25
18	A.G.Z. Bonn Cat., No. 16955	22 34 20·84	+1·54	+43 47 11·2	− 3·7	26
26	A.G.Z. Helsingfors, No. 11465	20 30 10·99	+2·30	+55 37 23·7	− 7·4	27
27	A.G.Z. Helsingfors, No. 11116	20 5 16·47	+2·43	+56 23 11·1	− 7·4	28
29	A.G.Z. Helsingfors, No. 10399	19 18 24·81	+2·77	+57 27 14·7	− 7·4	29
29	Radcliffe 1st Cat., No. 4148	19 12 7·10	+2·78	+57 31 52·9	− 7·4	30
30	A.G.Z. Helsingfors, No. 10059	18 52 1·15	+2·89	+57 21 30·2	− 7·1	31

Date 1899.	Star's Designation or Authority for Places.	Mean R.A. Equinox of Year. h m s	Correction to Mean R.A. s	Mean Declination. Equinox of Year. ° ′ ″	Correction to Mean Declination.	No. of Reference.
31	45 Draconis; Helsingfors, No. 9856	18 30 50·02	+3·00	+56 58 7·1	− 6·7	32
31	A.G.Z. Helsingfors, No. 9789	18 23 27·57	+3·01	+56 55 32·9	− 6·7	33
June 1	Bonn, Vol. VI. +56°, No. 2058	18 1 0·56	+3·12	+56 22 1·6	− 6·2	34
2	A.G.Z. Helsingfors, No. 9436	17 42 1·25	+3·19	+55 11 56·8	− 5·8	35
2	A.G.Z. Helsingfors, No. 9430	17 41 19·11	+3·19	+55 12 29·7	− 5·8	36
4	A.G.Z. Cambridge Cat., No. 5133	16 58 55·12	+3·27	+52 44 57·1	− 4·9	37
5	A.G.Z. Cambridge Cat., No. 5092	16 48 25·27	+3·28	+51 17 57·3	− 4·5	38
5	A.G.Z. Cambridge Cat., No. 5070	16 42 6·69	+3·29	+51 17 42·3	− 4·5	39
6	A.G.Z. Cambridge Cat., No. 5008	16 25 37·50	+3·30	+49 53 19·8	− 4·2	40
8	A.G.Z. Bonn Cat., No. 10402	16 9 12·15	+3·28	+46 28 34·9	− 3·8	41
8	Bonn, Vol. VI. +46°, No. 2142	15 59 38·78	+3·28	+46 19 3·7	− 3·8	42
9	A.G.Z. Bonn Cat., No. 10192	15 48 33·66	+3·27	+44 59 57·4	− 3·7	43
9	A.G.Z. Bonn Cat., No. 10201	15 49 26·84	+3·27	+44 49 21·9	− 3·7	44
10	A.G.Z. Bonn Cat., No. 10174	15 46 3·14	+3·26	+43 9 8·9	− 3·7	45
12	A.G.Z. Bonn Cat., No. 9984	15 26 24·47	+3·24	+40 15 15·4	− 3·6	46
12	Radcliffe, No. 3395; A.G.Z. Bonn Cat., No. 9987	15 26 36·75	+3·23	+40 2 25·8	− 3·6	47
13	Paris Cat., No. 19126; A.G.Z. Lund Zone 6	15 20 31·89	+3·22	+38 32 53·9	− 3·6	48
14	W.B. XI. No. 199; A.G.Z. Lund Zones	15 11 8·69	+3·20	+37 12 16·2	− 3·7	49
15	Rü, No 4958; A.G.Z. Lund Zones	15 4 5·56	+3·18	+35 37 21·8	− 3·8	50
16	A.G.Z. Leiden Zones, No. 42	15 3 2·03	+3·17	+34 21 14·9	− 3·9	51

Tuttle's Comet.

Date 1899.	Star's Designation or Authority for Places.	Mean R.A. Equinox of Year. h m s	Correction to Mean R.A. s	Mean Declination. Equinox of Year. ° ′ ″	Correction to Mean Declination. ″	No. of Reference.
April 4	A.G.Z. Berlin B. Zones, No. 953	3 9 42·03	+0·89	+22 50 19·9	+ 5·4	52
10	A.G.Z. Berlin B. Zones, No. 1084	3 33 8·30	+0·92	+20 35 11·1	+ 4·3	53

Tempel II., Comet, 1899 IV.

July 26	Washington Zones, 1889; Frisby, 9334	20 45 39·09	+4·64	−21 24 12·5	+18·2	54
28	Radcliffe Cat., Stone, No. 5636	20 51 2·17	+4·66	−22 23 35·0	+18·6	55
30	Radcliffe Cat., Stone, No. 5656	20 55 33·18	+4·72	−23 28 24·4	+18·9	56
Aug. 1	Washington Zones, 1889, Frisby, No. 9378	20 51 8·08	+4·78	−24 34 59·2	+18·8	57

Comet 1899 V (Giacobini).

Oct. 4	Paris Catalogue, No. 20771	16 28 39·67	+2·70	− 3 34 39·5	− 1·1	58
8	Munich Neue Annalen, Bd. I., No. 12965	16 38 40·76	+2·69	− 2 26 26·3	− 0·1	59
9	Göttingen No. 2, No. 4097	16 46 0·71	+2·67	− 2 2 32·0	+ 0·7	60

Liverpool Observatory: 1900 *April* 10.

Errata in Mr Ellis's Paper.

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